US Army Corps of Engineers
St. Paul District

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DESIGN MEMORANDUM NO. 6
FLOOD CONTROL PROJECT

BEAR CREEK
STAGE 4

ROCHESTER, MINNESOTA

20050727 130

MAY 1992

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
May 1992

2. REPORT TYPE
Final

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Bear Creek Stage 4 Rochester, Minnesota: design memorandum no. 6.

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers, St. Paul District
190 5th St. E.
St. Paul, MN 55101

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
This report presents the recommended design for Stage 4 on Bear Creek. The design includes channel modifications, two drop structures, tie-back levee, recreational trail, relocation/replacement of existing pedestrian bridges and relocations of existing utilities and sewers.

15. SUBJECT TERMS
Flood control
Rochester, Minnesota   Flood damage prevention

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
Unclassified	Unclassified	Unclassified			19b. TELEPHONE NUMBER *(Include area code)*

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1421 U.S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101-1479

125 YEARS 1866-1991 US Army Corps of Engineers St Paul District

REPLY TO
ATTENTION OF

CENCS-ED-M (1110) 6 May 1992

MEMORANDUM FOR Commander, North Central Division, ATTN: CENCD-PE-ED, 111 North Canal Street, Chicago, Illinois 60606-7205

SUBJECT: Flood Control, South Fork Zumbro River at Rochester, Minnesota, Design Memorandum No. 6, Stage 4, Bear Creek

1. Subject report is submitted in accordance with EC 1110-2-265 for your review and approval.

2. This design memorandum presents the design improvements for construction of channel modifications and related structures as well as recreational features for Bear Creek, a tributary of the South Fork Zumbro River in Rochester, Minnesota.

Encl (16 cys)
Rochester DM

RICHARD W. CRAIG
Colonel, EN
Commanding

FLOOD CONTROL
SOUTH FORK ZUMBRO RIVER AT
ROCHESTER, MINNESOTA

DESIGN MEMORANDUM NO. 6
STAGE 4

DESIGN MEMORANDUM SCHEDULE

Number	Scheduled Completion	Submitted NCD	Submitted HQUSACE	Approved
1 - Phase 1 General	Aug 77	Aug 77		Apr 79
1 - Phase 2 General	Sep 82	Sep 82		Feb 83
2 - Stage 1B	Dec 86	Feb 87		Jan 89
3 - Stage 2A	Jun 91	Jun 91		Aug 91
4 - Stage 2B	May 90	Apr 90		May 90
5 - Stage 3	Aug 90	Aug 90		May 91
5 - Stage 3 Sup.	Aug 92			
6 - Stage 4	May 92	May 92		

PERTINENT DATA

Project Document -- House Document 93-156, 93rd Congress, 1st Session.

Project Authorization -- 1986 Water Resource Development Act (Public Law 99-662)

Project Purposes -- Flood Control and Recreation

Location -- Rochester is in Olmsted County in southeastern Minnesota on the South Fork Zumbro River, a tributary of the Mississippi River.

Hydrology and Hydraulics

Watershed drainage area	304 Sq. Mi.
Design flood frequency (when combined with a system of seven headwaters reservoirs under construction by Soil Conservation Service)	Approx. 0.05 percent
Design flows	
Silver Lake Dam to Silver Creek	22,000 cfs
Silver Creek to Bear Creek	21,500 cfs
Upstream of Bear Creek	16,800 cfs
Bear Creek	9,700 cfs

Principal Items of Work

Channel Improvement	
Riprap lined	6.6 miles
Concrete lined	0.9 mile
Dredged	0.5 mile
Drop Structures	4
New levees	
Primary levees	1.3 miles
Tie-back levees	0.5 mile
Dam Modifications	1
Relocations	
Bridge modifications	21
Bridge replacements	4
Utility crossings	37
Bicycle and hiking trails	9 miles
Footbridge replacements	11
New footbridges	2
Wildlife mitigation area	142 acres

SYLLABUS

The Rochester, Minnesota flood control project was authorized for construction by Section 401(a) of the Water Resource Development Act of 1986, Public Law 99-662.

The project is located in Rochester in Olmsted County in southeastern Minnesota, approximately 70 miles south of Minneapolis-St. Paul. A potential exists for catastrophic flood damages in Rochester, where more than one-third of the city lies within the floodplain formed by the South Fork Zumbro River and Bear, Cascade and Silver Creeks. Major floods have occurred four times during the past 29 years. The flood of record occurred in July 1978 causing a loss of 5 lives and estimated damages of $58.8 million. Losses from a recurrence of this flood could exceed $133.6 million in October 1991 price levels.

The authorized project consists of channel modifications, including widening and deepening the existing channel, and riprap, concrete, and steel sheet-pile bank protection, on the South Fork Zumbro River, Cascade Creek, and Bear Creek. Principal project features include 6.6 miles of riprap-lined channel, 0.9 mile of architecturally-treated concrete channel, 0.5 mile of dredged channel, 4 drop structures, 1.8 miles of levees, and recreation features that include hiking and bicycling trails. The project, when combined with a system of upstream reservoirs under construction by the Soil Conservation Service (SCS), will protect Rochester against approximately the 0.5 percent chance (220-year flow frequency) flood.

This design memorandum presents the recommended design for Stage 4 on Bear Creek. The design includes approximately 7000 feet of channel modifications, two drop structures, 3600 feet of tie-back levee, approximately 10,000 feet of recreational trail, relocation/replacement of three existing pedestrian bridges, and relocations of existing utilities and sewers.

The total estimated project cost is $123,200,000. Federal costs are estimated at $90,800,000; Non-Federal costs are estimated at $32,400,000. The benefit-cost ratio is 1.13. The estimated cost for stage 4 is $17,753,000.

The Local Cooperation Agreement was executed in August 1987. The first construction contract was awarded in September 1987. Five additional construction contracts for channel modifications on the South Fork Zumbro River were awarded in fiscal years 1988, 1989, 1990 and 1992.

The SCS is constructing a system of seven flood prevention reservoirs, recreation facilities, and accelerated land treatment measures in the upper watershed. Without the SCS reservoirs, some areas of Rochester would receive less than 100-year protection from the Corps project alone. Construction of two reservoirs on Willow Creek is complete. Construction is underway on two reservoirs, one on Silver Creek and one on Bear Creek. The SCS project is scheduled for completion in June 1995.

FLOOD CONTROL
BEAR CREEK
ROCHESTER, MINNESOTA

DESIGN MEMORANDUM NO. 6
STAGE 4

TABLE OF CONTENTS

PARAGRAPH	DESCRIPTION	PAGE
	DESIGN MEMORANDUM SCHEDULE	
	PERTINENT DATA	
	SYLLABUS	
1	SCOPE AND LOCATION	1
2	PROJECT AUTHORIZATION	1
3	PROJECT DESCRIPTION	1
4	DESCRIPTION OF EXISTING FEATURES	1
5-6	DEPARTURES FROM APPROVED GDM	1
7-8	HYDROLOGY AND HYDRAULICS	2
9-11	GEOLOGY AND GEOTECHNICAL ENGINEERING	2
	ALTERNATIVE PLANS CONSIDERED	3
12-13	LIMITED CHANNEL MODIFICATIONS ALTERNATIVE	3
14	SCOUR PROTECTION ALTERNATIVES	3
15	ALTERNATIVE DROP STRUCTURES	4
16	COST SAVING MEASURES	4
17	VALUE ENGINEERING	4
	DESCRIPTION OF PROPOSED STRUCTURES AND IMPROVEMENTS	5
18-20	CHANNELS	5
21-22	DROP STRUCTURES, OVERFLOW STRUCTURES, AND TIE-BACK LEVEES	5
23-24	BRIDGES	6
25-26	RETAINING WALLS	6
27-28	RECREATIONAL PATHS AND UNDERPASSES	6
29	INTERIOR FLOOD CONTROL	7
30	SIDE CHANNEL INLETS	7
31	STORM AND SANITARY SEWER MODIFICATIONS	7

TABLE OF CONTENTS (continued)

PARAGRAPH	DESCRIPTION	PAGE
	ENVIRONMENTAL ANALYSIS	7
32-34	ENVIRONMENTAL SETTING	7
35-37	ENVIRONMENTAL IMPACTS	8
38	WATER QUALITY	9
39-42	CULTURAL RESOURCES	9
43-45	RECREATION, LANDSCAPE DEVELOPMENT AND AESTHETIC CONSIDERATIONS	9
46	MEASURES FOR PHYSICAL SECURITY AND SAFETY	10
47	HANDICAPPED FACILITIES	10
48	SOURCES OF CONSTRUCTION MATERIALS	10
49	AGGREGATE AND GRANULAR MATERIALS	10
50	CONCRETE AGGREGATE	10
51	OTHER CONSTRUCTION MATERIALS	11
52-55	CONSTRUCTIBILITY	11
56	ACCESS ROADS	12
57-59	REAL ESTATE REQUIREMENTS	12
	RELOCATIONS	12
60	UTILITIES	12
61	ROADS AND BRIDGES	13
62	COORDINATION	13
63-64	COST ESTIMATE	13
65	CURRENT BENEFIT-COST ANALYSIS	15
	SCHEDULE FOR DESIGN AND CONSTRUCTION	15
66	DESIGN	15
67	CONSTRUCTION	16
68	FUNDING SCHEDULE	16
69	POST AUTHORIZATION CHANGES	16
70	OPERATION AND MAINTENANCE	16
71	RECOMMENDATION	16

TABLES

NUMBER	TITLE	PAGE
1	SUMMARY COMPARISON OF ESTIMATED FIRST COSTS	13
2	BENEFIT-COST ANALYSIS	15

TABLE OF CONTENTS (continued)

PLATES

PLATE NO.	TITLE
1	Location Map, Vicinity Map and Drawing Schedule
2	General Plan
3	Plan and Profile - Station 0+00 to 10+00
4	Plan and Profile - Station 10+00 to 20+00
5	Plan and Profile - Station 20+00 to 30+00
6	Plan and Profile - Station 30+00 to 40+00
7	Plan and Profile - Station 40+00 to 50+00
8	Plan and Profile - Station 50+00 to 60+00
9	Plan and Profile - Station 60+00 to 69+00
10	Plan and Profile - Station 69+00 to 75+35
11	Plan and Profile - Station 0+00R to 9+35R
12	Plan and Profile - Station 0+00L to 9+00L
13	Plan and Profile - Station 9+00L to 20+00L
14	Plan and Profile - Station 20+00L to 29+00L
15	Channel Sections 1-3 - Station 3+71 to 5+71
16	Channel Sections 4-6 - Station 8+00 to 11+90
17	Channel Sections 7-9 - Station 11+90 to 13+00
18	Channel Sections 10-12 - Station 13+00 to 14+90
19	Channel Sections 13-15 - Station 14+90 to 23+75
20	Channel Sections 16-18 - Station 25+00 to 39+00
21	Channel Sections 19-21 - Station 39+00 to 47+00
22	Channel Sections 22-24 - Station 47+00 to 61+00
23	Channel Sections 25-27 - Station 63+00 to 66+00
24	Channel Sections 28-30 - Station 68+83 to 71+10
25	Channel Sections 31-33 - Station 71+80 to 73+50
26	Right Levee Sections 1-3 - Station 0+71R to 9+35R
27	Left Levee Sections 1-4 - Station 0+71L to 29+00L
28	4th Street SE Underpass & Scour Protection - Plan, Elevations, and Sections
29	6th Street Bridge - Plan, Elevation, & Sections
30	6th Street Bridge Wing Walls - Plan and Elevations
31	Retaining Walls - Elevations & Sections
32	U.S. 14 Bridge - Plan, Elevations and Sections
33	U.S. 14 Bridge - Plan, Elevation and Sections
34	Bridges 1, 2, & 3 - Plan and Sections
35	RCP Culvert with Flap Gate Sta. 18+50L - Plan, Elevations, and Sections
36	Downstream Drop Structure & Wingwalls - Plan and Section
37	Downstream Drop Structure & Wingwalls - Sections
38	Upstream Drop Structure & Wingwalls - Plan and Sections
39	Upstream Drop Structure & Wingwalls - Sections
40	Sanitary Sewer Siphon Profile and Details - Station 51+80
41	Storm Sewer Schedule and Details
42	Storm Sewer Outlet - Plan, Elevation and Section
43	Landscape and Lighting Plan - Station 0+00 to 10+00
44	Landscape and Lighting Plan - Station 10+00 to 20+00
45	Landscape and Lighting Plan - Station 20+00 to 30+00
46	Landscape and Lighting Plan - Station 30+00 to 40+00

TABLE OF CONTENTS (continued)

PLATES (continued)

PLATE NO.	TITLE
47	Landscape and Lighting Plan - Station 40+00 to 50+00
48	Landscape and Lighting Plan - Station 50+00 to 60+00
49	Landscape and Lighting Plan - Station 60+00 to 69+00
50	Landscape and Lighting Plan - Station 69+00 to 75+35
51	Landscape and Lighting Plan - Station 0+71R to 7+35R
52	Landscape and Lighting Plan - Station 0+00L to 9+00L
53	Landscape and Lighting Plan - Station 9+00L to 20+63L

APPENDIXES

APPENDIX A: Hydraulic Design
APPENDIX B: Interior Flood Control
APPENDIX C: Geotechnical Design
APPENDIX D: Structural Analysis and Design
APPENDIX E: Recreational, Landscape Development and Aesthetic Considerations
APPENDIX F: Detailed Estimate of Cost
APPENDIX G: Correspondence

FLOOD CONTROL
BEAR CREEK
ROCHESTER, MINNESOTA

DESIGN MEMORANDUM NO. 6
STAGE 4

SCOPE AND LOCATION

1. The flood protection project at Rochester, Minnesota, is divided into 10 stages of construction. This Design Memorandum (DM) presents the design for Stage 4, Bear Creek. This stage consists of channel modifications to Bear Creek extending from the confluence with the South Fork Zumbro River upstream to Mayo High School. The work includes approximately 7,000 feet of channel modifications, construction of two drop structures, and construction of approximately 3,600 feet of flood levee. Recreational features include approximately 10,000 feet of bicycle and pedestrian trails along the flood control channel and levee, and replacement of three pedestrian bridges.

PROJECT AUTHORIZATION

2. This project was authorized for construction under Public Law 99-662, 99th Congress 17 November 1986.

PROJECT DESCRIPTION

3. The 10 construction stages are as follows: eight stages on the South Fork Zumbro River and one stage each on Cascade and Bear Creeks. Six stages on the South Fork Zumbro River are currently under construction or completed.

DESCRIPTION OF EXISTING FEATURES

4. The Stage 4, Bear Creek, project is located in a residential/commercial area in southeastern Rochester. The existing channel varies from steep banks with brush to gentle banks with grass and trees. There are a few retaining walls to support yards or businesses. Homes and some businesses are located close to the meandering creek. Two parks are located on the creek within the project limits: Slatterly Park and Bear Creek Park.

DEPARTURES FROM APPROVED GDM

5. The design presented here essentially conforms to that shown in Design Memorandum No. 1, Phase 2, General Project Design, September 1982 (GDM). Changes since the completion of the GDM are as follows:

a. The scour protection for the channel has been modified. The GDM employed riprap, gabions, or existing rock across the entire channel section. Vegetation of slopes has been added and in some areas interlocking slope protection will be used in place of riprap. The channel bottom in Slatterly Park, that is not protected by exposed bedrock, will not receive scour protection.

Instead, toe protection of the low flow side slopes will be provided.

b. The channel design has been modified as follows. The channel bottom was widened between station 6+40 at the 4th St SE bridge and the downstream drop structure at station 13+00. Between station 6+40 and station 33+35 just upstream of Slatterly Park, the side slopes were changed to 1V:3H above the 20-yr. flow line. Below the 20-year flow line the side slopes remain at 1V:2.5H. From station 37+05 to 61+00 through Slatterly Park, the low flow channel was enlarged and from station 63+00 to 71+33 upstream of US Highway 14 a low flow channel was added.

c. The channel alignment between stations 7+00 and 14+00 has been changed to improve the hydraulic channel radius.

d. The upstream drop structure at station 71+70 was redesigned and relocated approximately 600 feet upstream. The overflow embankments were redesigned replacing the gabions with turf covered riprap. The downstream drop structure was relocated approximately 200 feet downstream, to station 13+00, to avoid impacts on the Convalescent Home. Curved abutments were added to both drop structures and wingwalls were eliminated from the downstream drop structure.

e. The tie-back levee at the upstream end of Bear Creek has been reduced in length and height. The levee height was reduced from the standard project flood (SPF) plus freeboard to the design water surface plus freeboard. This allowed the levee to be tied in closer to the drop structure, reducing the length of the levee from 7000 feet to 3600 feet. The gatewells crossing the levee have also been eliminated.

6. Details of all of these modifications are presented in the Hydraulics Design and Interior Flood Control Appendices (Appendices A and B).

HYDROLOGY AND HYDRAULICS

7. The hydraulic and hydrologic data for South Fork Zumbro River and Bear Creek are included in DM No. 1, General, Phase 1, Plan Formulation, August 1977. An updated discharge-frequency curve and data for the 1978 flood of record are in the GDM.

8. Appendix A of this DM includes an introduction discussing changes to the GDM design for Bear Creek and presents the hydraulic design for the channel modifications, drop structures, and scour protection. Also included are discussions of channel maintenance and stability. The interior flood control design is presented in Appendix B. This includes an introduction discussing changes to the GDM and presents the hydrologic and hydraulic design of interior drainage swales, side channel inlets, storm sewer outlets, and associated erosion control.

GEOLOGY AND GEOTECHNICAL ENGINEERING

9. A description of the geology for the project area is presented in the GDM and in the Geotechnical Design Appendix (Appendix C). Appendix C also discusses subsurface investigation and testing programs performed to date, characteristics of site overburden and bedrock, engineering properties of

materials used in engineering computations, slope stability and bearing capacity analyses, rock excavation methods, and soil and rock characteristics that will affect construction.

10. The subsurface stratigraphy along Bear Creek consists generally of alluvial sands and gravel overlying bedrock. Two drop structures are included in Bear Creek. The downstream drop structure will be founded directly on bedrock. Three existing pedestrian bridges will be replaced as part of Bear Creek construction. The piers and abutments for two of the bridges will be founded directly on bedrock.

11. A considerable quantity of bedrock must be removed to widen and deepen the river channel. Bedrock consists generally of interbedded layers of dolomitic limestone, sandstone, and, to a lesser amount, shale. Generally, the top few feet of bedrock is weathered and fractured to some degree. On the basis of visual observations of rock outcrops in the river channel, rock obtained during subsurface investigations and the results of laboratory testing of rock core samples, the rock that will be excavated along Bear Creek is similar to previous stages of construction that have been completed on the South Fork Zumbro River. Experience during construction on the Zumbro River has been that the majority of bedrock excavated is marginally rippable to nonrippable. The anticipated rock excavation method includes blasting. Further discussion is given in Appendix C.

ALTERNATIVE PLANS CONSIDERED

LIMITED CHANNEL MODIFICATIONS ALTERNATIVE

12. The Bear Creek channel was reviewed to determine if the modification of limited, localized channel reaches and bridge underpasses would reduce the 100-year water surface profile sufficiently to remove the majority of the Bear Creek residents from the floodplain. The alternative design developed would have eliminated the upstream drop structure and tie-back levee as well as reducing the length and extent of channel work. These changes would have significantly reduced construction costs and real estate requirements. This design alternative is discussed further in Appendix A.

13. The alternative design would not protect some houses and other buildings from the 100 year event and would not include any channel freeboard. The loss in benefits, due to reduced flood protection and the loss of recreation benefits, reduced the benefit cost ratio. A flood event, well in excess of the design flood, occurred on Bear Creek in 1978, resulting in extensive damage and the loss of four lives. As a result of this flood, and the rapid rate of rise of Bear Creek during flood events, any reduction in the level of protection is unacceptable to the local sponsor. Therefore, despite significant construction cost savings by the reduced plan, the GDM design was selected.

SCOUR PROTECTION ALTERNATIVES

14. The channel design shown in the GDM called for riprap or existing rock protection for the entire channel section in Slatterly Park from station 37+05 to 61+00. The following alternatives were considered for the low flow channel design:

a. To allow the low flow channel to scour and meander while restricting the scour at the limits of the high flow channel.
b. Placing riprap from bank to bank of the low flow channel.
c. Placing riprap slope protection on the slopes of the low flow channel and leaving the channel bottom unprotected.
d. Placing interlocking slope protection on the slopes of the low flow channel and leaving the channel bottom unprotected.

The following alternatives were considered for protection of the high flow channel side slopes and bench:

e. Placement of reinforced turf.
f. Use of a reduced riprap and bedding layer under topsoil and turf.
g. Placing interlocking slope protection.

Scour protection alternatives are discussed further in Appendix C.

ALTERNATIVE DROP STRUCTURES

15. An alternative drop structure design, for use at both drop structures, is being considered to increase safety. The design would be a cascade type structure using steps downstream of the weir. This would eliminate or reduce the roller formed during flooding and reduce the vertical drop from the weir during low flows. Any revisions to the design presented in this DM will be submitted for review under separate cover. The alternative drop structure design is discussed in Appendix A.

COST SAVING MEASURES

16. Several refinements were made to the project design within Stage 4 as cost savings measures:

a. The levee was reduced in height and length. This did not change the level of protection from the design flood event.
b. The two gatewells in the levee were eliminated. One drainage area is no longer enclosed by the levee and therefore, no gatewell is needed. In the case of the other gatewell, a smaller pipe with a flapgate will cross the levee at station 18+50L. For events in excess of the design event, flow will be routed in a drainage swale to Bear Creek at station 67+50, downstream of the drop structure.
c. The low flow channel from stations 33+35 to 68+83 was increased in width and depth. This reduced the velocities along the high flow channel side slopes and bench allowing the use of turf without riprap, except in transitions and the outside of bends. Also a native soil channel bottom will be used for the low flow portion of the channel.

VALUE ENGINEERING

17. A value engineering study is scheduled to begin in June 1992 for the proposed Stage 4 design, upon completion of the design memorandum.

DESCRIPTION OF PROPOSED STRUCTURES AND IMPROVEMENTS

CHANNELS

18. Channel improvements on Bear Creek will extend from the confluence with South Fork Zumbro River upstream 7,000 feet to Mayo High School. The project consists primarily of widening and deepening of the existing channel and providing appropriate scour protection. The channel will be excavated 2 to 6 feet below the existing channel bottom and bottom widths will vary from 60 to 140 feet. Because of the diverse nature of the channel design, the discussion of the channel design is broken into two reaches. They are:

Reach	Location	Station
	Mouth of Bear Creek	2+50
1	to	
	D/S End of Slatterly Park	33+35
2	to	
	Upstream Drop Structure	71+33

19. For reach 1, the channel bottom width will be 60 to 110 feet. Downstream of the 4th St SE bridge at station 6+40, the side slopes will be 1V:2.5H and 1V:3H on the left and right banks respectively. Interlocking slope protection will be used on the right bank to match the in-place construction of Stage 1B-3. Upstream of station 6+40 the channel bottom width will range from 110 to 60 feet. Side slopes will be 1V:2.5H from the channel bottom to an elevation 8 1/2 feet above the invert and will be protected by riprap. From this point, side slopes are 1V:3H to the top of bank and will be protected by riprap covered with seeded topsoil. The channel bottom will be protected by riprap from the mouth to the intersection of excavated rock near station 11+30. The remainder of the channel bottom for this reach will be exposed rock. From station 24+80 to station 25+30, walls will parallel the channel near the 6th St SE bridge to minimize the channel top width and avoid relocation or modification of the bridge and 9th Ave SE.

20. The channel for reach 2 will consist of a 65 foot wide, 7 foot deep, low flow channel with 22 1/2 foot wide high flow bench on each side. All side slopes will be 1V:3H. The low flow channel in Slatterly Park will be excavated in rock upstream to station 47+00. The low flow channel side slopes upstream of Station 39+00 in Slatterly Park will be protected by interlocking slope protection with riprap toe protection. The low flow channel side slopes upstream of US Highway 14, station 63+00, will be protected by riprap. The high flow bench and side slopes will be lined with turf; the outside of bends will be protected by topsoil and turf over riprap. With the exception of channel transitions and exposed rock, the channel bottom will be left as native soils. A meandering low flow channel will be allowed to form within the low flow channel bottom as part of the project Fish and Wildlife mitigation.

DROP STRUCTURES, OVERFLOW STRUCTURES, AND TIE-BACK LEVEES

21. A drop structure will be constructed at station 13+00 and is founded on existing bedrock. Its purpose is to control channel velocities by

conveying flows from a higher elevation to a lower elevation and dissipate energy in the process. The structure is capable of passing flows in excess of the design event.

22. At the upstream end of the channel modification, station 71+70, a drop structure will be constructed to prevent degradation of the upstream channel. A low flow notch will be provided to prevent ponding upstream of the weir during low flows. The concrete drop structure is designed to pass flows up to the design event. For greater discharges, flood water will flow over the right and left overflow embankments. The resulting high flow headwater elevations and low flow velocities do not exceed existing conditions. The overflow embankments will be constructed of seeded topsoil over riprap and will be tied into high ground on both banks with tie-back levees. The levees provide 2 feet of freeboard above the design event.

BRIDGES

23. The channel will be deepened 3 to 5 feet beneath the existing 4th Street SE, 6th Street SE, and US Highway 14 bridges. Additional scour protection will be provided along the side slopes and channel bottom at the approaches and under the bridges. Concrete scour protection will be provided for the piers and left abutment at US Highway 14 east bound bridge, and the left abutments for 6th Street SE and 4th Street SE. The right bank abutments will be protected by the adjacent underpasses. The wingwalls of the bridges will also be extended. Three existing pedestrian bridges will be removed and replaced as part of this project. Bridges are discussed in detail in the Structural Appendix (Appendix D).

24. The Minnesota Department of Transportation (MnDOT) plans to replace the US Highway 14 west bound bridge. The project design and schedule has been and will continue to be coordinated with MnDOT. They will assure the footing depths and wingwalls accommodate the deepened channel. Plans for the proposed bridge replacement were incorporated into the hydraulic design.

RETAINING WALLS

25. Approximately 1300 feet of reinforced concrete retaining wall will be constructed along Bear Creek. These walls will provide for the trail underpasses and protect existing structures adjacent to the channel.

26. All of the existing stone and concrete retaining walls within this reach will be removed during channel modifications due to their location and footing depth. Retaining walls are discussed further in Appendix D.

RECREATIONAL PATHS AND UNDERPASSES

27. A 10 foot-wide multi-use recreational trail will parallel the channel, along the top of the right bank, with underpasses at each of the three traffic bridges. At the upstream end of the channel work, the path on the trail will cross the overflow embankment and connect to an existing trail in Bear Creek Park. The trail will also cross the upstream pedestrian bridge and follow the top of the left bank tie-back levee to approximate station 16+00L where it will tie into an existing trail. Access to the trail along the right bank will be at the end of existing dead end streets. Access from

the left bank will be at the three pedestrian bridges, and from the sidewalks of the 4th and 6th Street bridges. The recreational trail will also be used as a maintenance access for the flood control channel.

28. The recreational trail design uses slopes of 5 percent or less, making the trail accessible for the handicapped as well as for bicyclists. The trail will be illuminated for safety with directional globe fixtures similar in appearance to the globe light fixtures used on other stages of the project. The light fixtures will provide an average of 1 foot candle along the trail. Recreational paths and underpasses are discussed further in the Recreation, Landscape Development, and Aesthetic Considerations Appendix (Appendix E).

INTERIOR FLOOD CONTROL

29. Construction of the left bank tie-back levee requires interior flood control features for the Mayo High School area and the area near the Resurrection Catholic Church. For the Mayo High School area drainage swales will direct the run off toward the main channel where the flow will enter Bear Creek via a side channel inlet. Drainage for the church area will pass under the levee through a 48" flap gated culvert. Flows in excess of the design event will flow into the swale for the high school area.

SIDE CHANNEL INLETS

30. There are four existing side channel inlets downstream of the upstream drop structure, station 71+70. For three of the inlets, flow will be conveyed to the lower channel invert by a riprap protected 1V:4H slope. The remaining side channel inlet has existing bedrock along its channel bottom. The modified main channel is excavated through the existing bedrock and therefore, the side slope of the modified channel will simply meet the side channel inlet at the point of interception.

STORM AND SANITARY SEWER MODIFICATIONS

31. Sixteen existing storm sewer outlets, located along the project length, will be modified. Thirteen are modified due to the lowering and widening of the channel and three are modified due to bridge modifications. The modifications consist of nine drop manholes, four catch basins, two outlets with concrete headwalls, and five flared outlets onto exposed bedrock. Existing bedrock, riprap, or concrete will be used for scour protection at the outlets. Four catch basins will also be added. An existing sanitary sewer crossing under the channel will either be replaced with an inverted siphon or redirected away from the channel.

ENVIRONMENTAL ANALYSIS

ENVIRONMENTAL SETTING

32. Land use in this reach of Bear Creek is a mix of residential and commercial development. Woodlands along the lower portion of Bear Creek, downstream from the Highway 14 Bridge, station 62+00, are characteristic of an urban environment; they are highly disturbed with a limited understory. In many areas the woodlands are limited to one or two trees in width.

Upstream of Highway 14, the woodland areas are more extensive and only moderately disturbed. The most common tree species present include American elm, boxelder, sugar maple, green ash, cottonwood, basswood, and black willow.

33. Bear Creek is generally a slow meandering stream with a sand bottom, with the lower 2500 feet of the creek being fast flowing with a ledge rock, rubble and boulder substrate. Predominant fish species found in the creek are the common shiner, bluntnose minnow, fathead minnow, longnose dace, creek chub and white sucker. During periods of moderate to high flows, some game fish, such as white crappie and smallmouth bass, may move into the lower reaches of the creek.

34. There are no known or suspected sites where contaminated materials may be encountered within the work limits for Bear Creek. The borings taken along Bear Creek did not indicate the presence of any contaminants. The Minnesota Pollution Control Agency (MPCA) has no record of any potential sites in the Bear Creek reach of the Rochester Project.

ENVIRONMENTAL IMPACTS

35. Construction of the proposed features will cause the loss of streambank vegetation. These losses will be partially offset by landscape plantings. Mitigation for terrestrial losses associated with project construction will be provided with the acquisition and development of approximately 140 acres adjacent to the Keller Wildlife Management Area just southwest of Rochester. Development on the acquired lands includes plantings and trails. This mitigation feature is being constructed as part of the Stage 2B construction contract.

36. Channel construction will cause the loss of instream habitat. Mitigation features for aquatic habitat losses include the construction of a native soil channel bottom in a portion of Bear Creek that will allow a meandering low-flow channel to form. A meandering low-flow channel is also being constructed in portions of other reaches along the Zumbro River. Aquatic mitigation features also include the placement of large riprap along the low-flow channel to provide instream habitat. The low-flow channel will be allowed to stabilize before the large riprap is placed. It will take 3 to 5 years for the channel to stabilize. After that time, it will be determined where it would be the most beneficial to place the large riprap. Alternate instream structures, such as small wingdams or other types of current deflectors, may be installed in lieu of large riprap. The location, design and placement of aquatic habitat improvement features will be done through coordination with the Minnesota Department of Natural Resources and the U.S. Fish and Wildlife Service.

37. Design departures from the GDM have been evaluated. The proposed changes will not result in any substantive changes in impacts from what was described in the Environmental Impact Statement, dated January 1979, or the Supplemental Information report, dated August 1982. Therefore, additional NEPA documentation is not necessary.

WATER QUALITY

38. Only riprap and bedding from approved quarries will be placed in the channel. Material excavated from the channel will be used for temporary earth berms to divert water. Excavation and blasting will cause a temporary increase in turbidity during construction. Levels of turbidity would return to normal after construction. No long-term ponding of water, change of runoff characteristics, or operational procedures that would affect water quality would be associated with the proposed project. The Section 404(b)(1) evaluation, which further addresses water quality impacts, is in the 1982 Supplemental Information Report.

CULTURAL RESOURCES

39. In accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, the National Register of Historic Places has been consulted. As of December, 1991, there are twenty-four properties listed on the National Register in Olmsted County, Minnesota. Fifteen properties, including fourteen buildings and one residential historic district, are located in the corporate limits of the city of Rochester. Three additional National Register properties are listed for the Rochester vicinity. None of these properties will be affected by the Rochester Flood Control Project.

40. There have been thirteen cultural resources surveys conducted for the Rochester-South Fork Zumbro Flood Control Project since 1975. In 1975, 1976, and 1981, four general cultural resources surveys for the entire Rochester project were undertaken. The first survey identified five prehistoric and six historic sites in the project area. The 1981 survey did not locate any additional sites. The 1981 survey also reexamined three of the sites identified in earlier surveys that potentially would have been impacted by the project. None of these three sites was found to be significant. In 1978 and 1982, archaeologists surveyed the Bear Creek stage. These surveys did not locate any cultural resources in the Bear Creek reach of the project. (The remaining cultural resources surveys relate to other stages of the Rochester project). To summarize, no sites have ever been located in the area to be impacted by Stage 4.

41. There are no sites listed on or potentially eligible for the National Register of Historic Places in Stage 4 of the Rochester Flood Control Project.

42. In compliance with Section 106 of the National Historic Preservation Act, as amended, Stage 4 Rochester Flood Control Project has been coordinated with the Minnesota State Historic Preservation Office.

RECREATION, LANDSCAPE DEVELOPMENT, AND AESTHETIC CONSIDERATIONS

43. The project will impact an existing Land and Water Conservation (LAW-CON) park, named Bear Creek Park, upstream of station 63+00. The upstream drop structure, overflow embankments and tie-back levee are located in this park. Lands will be provided by the city to mitigate any loss in park land. Additional information is included in Appendix E.

44. A landscape development plan has been prepared for Stage 4. Plantings used in Stage 4 are consistent with those used in other stages of the project. Plantings will be used in the residential areas to separate the public recreational trail from private yards. All plant material has been selected for hardiness, ease of maintenance, seasonal color, and texture variation.

45. Placement of topsoil and grasses over the riprap above the 20-year flood elevation will enhance the visual quality of the project. In areas where a high flow channel is used the bench and banks will be protected by turf. In areas where bends or transitions require riprap for the high flow channel topsoil and grass will be placed over the riprap. For additional information see Appendix E.

MEASURES FOR PHYSICAL SECURITY AND SAFETY

46. The side walls of the drop structures will consist of high vertical walls. Chain link fencing will be used along these walls for safety. The trail near the upstream drop structure is routed away from the drop structure to discourage access. At the bridge underpasses and where walls are adjacent to the trail, handrails will be used for safety. Underpasses are provided to eliminate dangerous street crossings for recreational trail users. The underpasses will be lit to provide security and reduce vandalism. The wall mounted light fixtures will have polycarbonate "vandal-resistant" lenses.

HANDICAPPED FACILITIES

47. The path and access ramps have been designed with grades of less than 5% so that the path will be accessible to wheel chairs.

SOURCES OF CONSTRUCTION MATERIALS

48. Granular materials are not abundant in the Rochester area but are available. Pervious sand may be found in river basins. Coarse aggregate is not readily available naturally, and is manufactured from quarries. Semi-pervious fill can be obtained from on-site borrow in excavated areas.

AGGREGATE AND GRANULAR MATERIALS

49. Riprap, bedding and drainage fill is produced from operating quarries located within 15 miles of Rochester. These quarries have been used extensively by the Minnesota Department of Transportation and have been used on previous stages of construction of the Rochester Flood Control Project. Pervious fill is available from producing pits in the valleys of the South Fork Zumbro River and Cascade Creek. Coarse concrete aggregate is available from the same quarries mentioned above and fine aggregate is available from the pits also mentioned above.

CONCRETE AGGREGATE

50. Concrete aggregate of adequate quality can be obtained from two quarries in the Shakopee and Oneota formations within 15 miles of Rochester.

OTHER CONSTRUCTION MATERIALS

51. Random fill, semi-pervious fill and topsoil can be obtained from the project excavations. Concrete and precast concrete products are available from manufacturers within the city of Rochester.

CONSTRUCTIBILITY

52. Major construction activities for Stage 4 are primarily channel improvements and construction of related facilities on Bear Creek. The work includes the following major construction activities.

a. Removal of three existing pedestrian bridges; concrete, masonry, and stone walls; and the temporary sheet pile drop structure
b. Excavation and disposal of 265,300 cubic yards of soil
c. Excavation and disposal of 59,000 cubic yards of bedrock
d. Construction of a 13,500 cubic yard tie-back levee
e. Construction of 4,200 cubic yards of structural concrete slabs and walls
f. Construction of three pedestrian bridges
g. Placement of 50,800 cubic yards of riprap and bedding
h. Placement of 17,800 square yards of interlocking slope protection
i. Restoration and landscaping activities

53. Construction is recommended to begin at the downstream end of Bear Creek and proceed upstream. Excavation will be done in the wet to reduce the need for cofferdams and dewatering. Riprap may be placed without dewatering since normal flows in the widened channel will be low. Some minor berming may be used to direct flow away from the side slopes during placement of the interlocking slope protection. Construction of the drop structures will require dewatering and cofferdams to build one side of the drop structure at a time. In the case of the upstream drop structure the flow could be diverted around the structure to allow for construction. Construction of scour protection and concrete walls will also require cofferdams and dewatering. The construction procedures required are not considered to be of a specialty nature and all activities can be accomplished using ordinary equipment and methods.

54. MnDOT plans to replace the US Highway 14 west bound bridge during the time construction is planned for Bear Creek. This will require coordination during development of plans and specifications to determine the sequence of construction adjacent to the bridge.

55. Channel excavation will be in bedrock from approximate station 11+00 to station 47+00. It is anticipated that much of the rock will not be able to be excavated by ripping (see Geotechnical Appendix C). Rock which can not be ripped shall be removed by blasting, jackhammering or other approved means. Use of blasting is a concern due to the existence of a 10" gas main crossing under the channel near station 38+00. The line is placed in the bedrock under the channel and is believed to have minimal bedding to cushion vibrations. Therefore, the gas main will have to be shut down during blasting. The gas main could be shut down during warm weather when demand for heating is low. If blasting is required, the Contractor's blasting procedure shall conform to state and federal laws and municipal ordinances.

ACCESS ROADS

56. Public roads and streets will be used for access to project construction sites. To facilitate removal of excess soil and placement of riprap and bedding, it is anticipated that the contractor will construct temporary haul roads along both channel banks and within the limits of work. Typically there is about 50 feet between the edge of riprap and the limits of work.

REAL ESTATE REQUIREMENTS

57. The city of Rochester will provide, without cost to the United States, and as generally provided by the Local Cooperation Agreement, all real estate interests, to include borrow and disposal areas, required for construction and subsequent project maintenance of the project. The city will comply with all of the provisions of the Uniform Relocation Assistance and Real Property Acquisition Policy Act of 1970 (Public Law 91-646, as amended).

58. The Stage 4 flood control project will require approximately 50.31 acres of real estate. The real estate consists of approximately 54 separate ownerships of land which must be acquired in fee title, permanent and temporary easements. The real estate interests required for this project were estimated from project Right-of-Way drawings and acreages. A break down of Real Estate costs is included in the Detailed Estimate of Cost Appendix (Appendix F).

Fee Title (includes lands, improvements and damages)	5.42 acres
Permanent Channel Improvement Easements	43.34 acres
Temporary Construction Area Easements	1.55 acres

59. One of the tracts was a partial taking of a bowling alley property. The partial take seriously impacted the operation of the bowling alley. The appraisal indicated that the value of the partial take approached the fee value of the entire tract. Because of the probability of an inverse condemnation claim by the owner, the local sponsor decided to purchase the entire tract in fee. This decision allowed the channel to be realigned with an increased hydraulic radius, and resulted in the removal of two other tracts from the project.

RELOCATIONS

UTILITIES

60. Local utility companies will make all necessary relocations of telephone, electric power, and gas facilities in the project area. Relocations of an existing water main and replacement of a sanitary sewer with an inverted sanitary sewer siphon will be included in this project. Consideration is being given to a plan to reroute the sanitary sewer and avoid the need for a siphon. These utilities are located throughout the project.

ROADS AND BRIDGES

61. Three existing pedestrian bridges will be removed and replaced as part of Stage 4. Scour protection will be added at each existing traffic bridge over the project. Details are presented in Appendix D.

COORDINATION

62. The design for Stage 4 was developed through extensive coordination with the City of Rochester. Coordination was also done with adjacent landowners, utility companies, MnDOT and the Minnesota Department of Natural Resources (MDNR). Project timing and layout of utilities, trails and retaining walls were included in this coordination. Pertinent correspondence is included in Appendix G.

COST ESTIMATE

63. The estimate of costs in this DM is based on October 1992 price levels and reflects recent prices for similar work in the St. Paul District. Table 1 presents a comparison of the DM cost estimate for stage 4 with the current approved estimate, adjusted to October 1992 price levels. A detailed cost estimate is presented in Appendix F.

Table 1 - Summary Comparison of Estimated First Costs

Item	Current Approved Estimate (adjusted to October 1992 price levels)	Revised Estimate (October 1992 price levels)
Project first cost		
Relocations	$ 281,000	$ 577,000
Roads	1,477,000	479,000
Channels	7,205,000	6,881,000
Levees	3,469,000	601,000
Recreation	402,000	1,096,000
Diversion Structures	1,563,000	687,000
Planning, Engineering and design	2,240,000	2,269,000
Construction Management	620,000	672,000
Non-Federal first cost (LERRDS)		
Lands and damages	3,431,000	3,060,000
Relocations	592,000	558,000
TOTAL PROJECT FIRST COSTS	$21,280,000	$16,880,000

64. The decrease/increase in the first costs ($4,400,000) between this estimate ($16,880,000) and the M-CACES estimate ($21,280,000) is attributed to the following (- indicates decrease and + indicates increase over approved PB-3 estimate):

a. Relocations $ +296,000
Increase in utility modifications based on moving the costs of outlet modifications from the 09 channels and canals account to the 02 relocations account. This is in accordance with EC 1110-2-538, Civil Works Project Cost Estimating - Code of Accounts, dated, 28 February 1989. These costs are included as a federal first cost in accordance with the Rochester LCA agreement.

b. Roads, Railroads and Bridges $ -998,000
Decrease in roads is due to the elimination of the road raise due to the refined design of the upstream levee.

c. Channels and Canals $ -324,000
Decrease in channel costs based on moving costs for outlet modifications and on refined engineering and design including elimination of riprap in the channel through most of Slatterly Park.

d. Levees and Floodwalls $-2,868,000
Decrease in Levees based on refined engineering and design including reduction in the length and height of the upstream levee and changing from gabions to riprap overflow embankments.

e. Recreation Facilities $ +694,000
Increase in Recreation Facilities based on refined engineering and design. Landscaping for enhancement of the recreational trail was moved to this account. Costs for trail lighting and an underpass at 4th Street were also added.

f. Diversion Structures $ -876,000
Decrease in Diversion Structures based on refined engineering and design.

g. Planning, Engineering and Design $ +29,000
Increase due to refinements in the estimated work load.

h. Construction Management $ +52,000
Increase due to refinements in the estimated work load.

i. Lands and damages $ -371,000
Decrease based on refined engineering and design including reduction in lands required for levee construction.

j. Non-Federal Relocations $ -34,000
Decrease based on refined engineering and design.

CURRENT BENEFIT-COST ANALYSIS

65. The benefit-cost analysis for the project as developed for the fiscal year 1993 budget documents [the total project cost reflected in this analysis is $115,600,000 (October 1991 price levels) at an interest rate of 8 5/8 percent and with cost sharing as defined by the 1986 Water Resources Development Act] is presented in Table 2.

TABLE 2 - BENEFIT-COST ANALYSIS

	Last Estimate Presented to Congress (Oct 1990-8 5/8%)	Current Estimate (Applicable Rate) (Oct 1991-8 5/8%)	Percent of Benefits	Current Estimate (Oct 1991-8 3/4%)	Percent of Benefits
Benefits (Average Annual)	$12,566,700	$13,650,000	100 (A)	$13,666,000	100
Flood Control	(10,006,100)	(11,089,400)	(81)	(11,086,200)	(81)
Advance Replacement	(1,568,200)	(1,568,200)	(12)	(1,589,900)	(12)
Recreation	(992,400)	(992,400)	(7)	(989,900)	(7)
Annual Charges	10,513,900	12,071,000 (B)		12,274,400	
Federal	(7,521,600)	(8,609,300)		(8,759,000)	
Interest	7,519,900	8,607,300		8,757,000	
Amortization	1,700	2,000		2,000	
Non-Federal	(2,992,300)	(3,461,700) (B)		(3,515,400)	
Interest	2,608,700	3,078,000		3,131,700	
Amortization	600	700		700	
Recreation Maintenance & Operation	97,000	97,000		97,000	
Flood Control Maintenance & Operation	286,000	286,000		286,000	
Benefit-Cost Ratio	1.2	1.13 (C)		1.11	

(A) The benefit to cost ratio is based on benefits and costs which have been presented in the Supplement to the Post Authorization Change Report (October 1990 price level) and annualized at the specified discount rate.
(B) Increase due to increased first costs.
(C) Decrease in B/C ratio due to increased first costs

SCHEDULE FOR DESIGN AND CONSTRUCTION

DESIGN

66. Plans and specifications for stage 4 are scheduled to be completed in the third quarter of fiscal year 1993.

CONSTRUCTION

67. A continuing contract for stage 4 is scheduled to be advertised in the third quarter of fiscal year 1993. Award of the construction contract is scheduled for the fourth quarter of fiscal year 1993; construction is scheduled for completion in September 1995.

FUNDING SCHEDULE

68. On the basis on the revised estimate for this DM and the current schedule for completion of the project, the Federal funds required (by fiscal year) are as follows:

Funds allocated thru FY	1992	$38,458,000
Fiscal year	1993	15,100,000
	1994	22,500,000
	1995	14,742,000

POST AUTHORIZATION CHANGES

69. Reauthorization of the Rochester project is required because the total project cost estimate exceeds the Section 902 limitations of the Water Resources Development Act of 1986. A Post Authorization Change report addressing the project cost increase was submitted to CENCD in July 1990, forwarded to HQUSACE in October 1990, and provided to OMB for review in July 1991. OMB review was completed in March 1992. On 1 April 1992 the ASA provided a recommendation to Congress for project reauthorization as part of the 1992 Water Resources Development Act.

OPERATION AND MAINTENANCE

70. Under the terms of the LCA, the local sponsors will be responsible for the operation and maintenance (O&M) of the project. Major items of O&M include periodic inspections of the channel and structures; periodic removal of sediments and debris, especially after floods; cleaning and repair of the recreational trails and lighting; and care of the landscape plantings. Channel maintenance is discussed in appendix A.

RECOMMENDATION

71. I recommend the approval of the plan for Stage 4, Bear Creek at Rochester, Minnesota, flood control project as presented in this DM.

Richard W. Craig
Colonel, Corps of Engineers
District Engineer

DRAWING INDEX

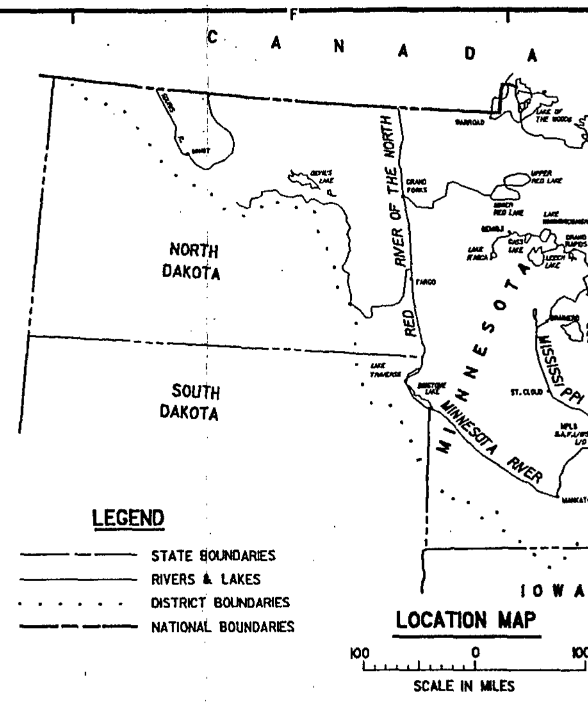
DRAWING	PLATE	DESCRIPTION
	1	LOCATION MAP, VICINITY MAP AND DRAWING SCHEDULE
	2	GENERAL PLAN
	3	PLAN AND PROFILE - STATION 0+00 TO 10+00
	4	PLAN AND PROFILE - STATION 10+00 TO 20+00
	5	PLAN AND PROFILE - STATION 20+00 TO 30+00
	6	PLAN AND PROFILE - STATION 30+00 TO 40+00
	7	PLAN AND PROFILE - STATION 40+00 TO 50+00
	8	PLAN AND PROFILE - STATION 50+00 TO 60+00
	9	PLAN AND PROFILE - STATION 60+00 TO 69+00
	10	PLAN AND PROFILE - STATION 69+00 TO 75+35
	11	PLAN AND PROFILE - STATION 0+00R TO 9+35R
	12	PLAN AND PROFILE - STATION 0+00L TO 9+00L
	13	PLAN AND PROFILE - STATION 9+00L TO 20+00L
	14	PLAN AND PROFILE - STATION 20+00L TO 29+00L
	15	CHANNEL SECTIONS 1-3 - STATION 3+71 TO 5+71
	16	CHANNEL SECTIONS 4-6 - STATION 8+00 TO 11+90
	17	CHANNEL SECTIONS 7-9 - STATION 11+90 13+00
	18	CHANNEL SECTIONS 10-12 - STATION 13+00 TO 14+90
	19	CHANNEL SECTIONS 13-15 - STATION 14+90 TO 23+75
	20	CHANNEL SECTIONS 16-18 - STATION 25+00 TO 39+00
	21	CHANNEL SECTIONS 19-21 - STATION 39+00 TO 47+00
	22	CHANNEL SECTIONS 22-24 - STATION 47+00 TO 61+00
	23	CHANNEL SECTIONS 25-27 - STATION 63+00 TO 66+00
	24	CHANNEL SECTIONS 28-30 - STATION 68+83 TO 71+10
	25	CHANNEL SECTIONS 31-33 - STATION 71+80 TO 73+50
	26	RIGHT LEVEE SECTIONS 1-3 - STATION 0+71R TO 9+35R
	27	LEFT LEVEE SECTIONS 1-4 - STATION 0+71L TO 29+00L

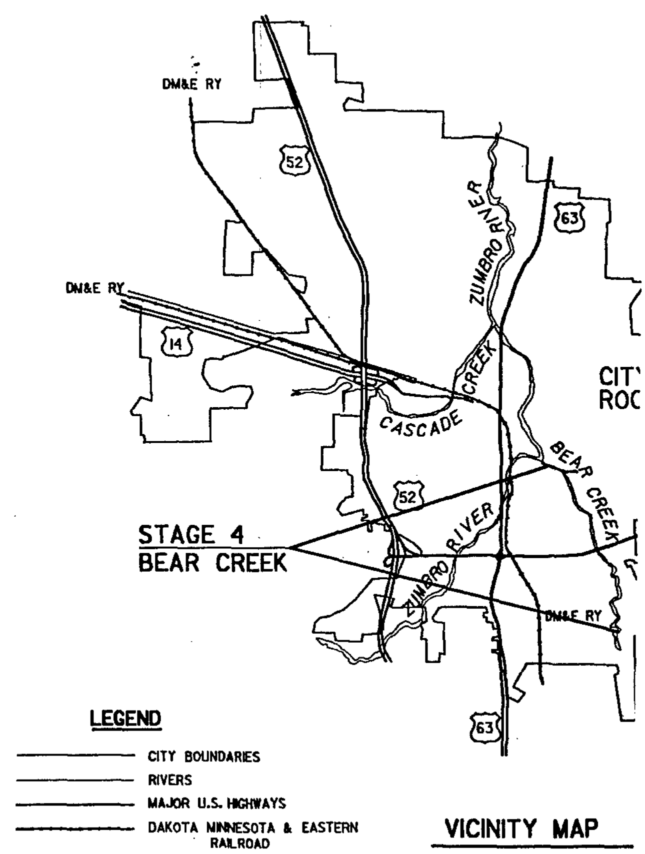
DRAWING INDEX

DRAWING	PLATE	DESCRIPTION
	28	4TH ST. SE UNDERPASS, SCOUR PROTECTION-PLAN, SECTIONS
	29	6TH STREET BRIDGE - PLAN, ELEVATION, & SECTIONS
	30	6TH STREET BRIDGE WING WALLS - PLAN AND ELEVATIONS
	31	RETAINING WALLS - ELEVATIONS & SECTIONS
	32	U.S. 14 BRIDGE- PLAN, ELEVATIONS AND SECTIONS
	33	U.S. 14 BRIDGE - PLAN, ELEVATION AND SECTIONS
	34	BRIDGES 1, 2, & 3 - PLAN AND SECTIONS
	35	RCP CULVERT WITH FLAP GATE STA. 18+50L- PLAN, ELEV.
	36	DOWNSTREAM DROP STRUCTURE & WINGWALLS - PLAN AND S
	37	DOWNSTREAM DROP STRUCTURE & WINGWALL SECTIONS
	38	UPSTREAM DROP STRUCTURE & WINGWALLS - PLAN AND SEC
	39	UPSTREAM DROP STRUCTURE & WINGWALL SECTIONS
	40	SANITARY SEWER SIPHON PROFILE AND DETAILS
	41	STORM SEWER SCHEDULE AND DETAILS
	42	STORM SEWER OUTLET - PLAN, ELEVATION AND SECTION
	43	LANDSCAPE AND LIGHTING PLAN - STATION 0+00 TO 10+00
	44	LANDSCAPE AND LIGHTING PLAN - STATION 10+00 TO 20+0
	45	LANDSCAPE AND LIGHTING PLAN - STATION 20+00 TO 30+0
	46	LANDSCAPE AND LIGHTING PLAN - STATION 30+00 TO 40+0
	47	LANDSCAPE AND LIGHTING PLAN - STATION 40+00 TO 50+C
	48	LANDSCAPE AND LIGHTING PLAN - STATION 50+00 TO 60+C
	49	LANDSCAPE AND LIGHTING PLAN - STATION 60+00 TO 69+C
	50	LANDSCAPE AND LIGHTING PLAN - STATION 69+00 TO 75+3
	51	LANDSCAPE AND LIGHTING PLAN - STATION 0+71R TO 7+3
	52	LANDSCAPE AND LIGHTING PLAN - STATION 0+00L TO 9+0C
	53	LANDSCAPE AND LIGHTING PLAN - STATION 9+00L TO 20+6

INDEX

DESCRIPTION
INDERPASS, SCOUR PROTECTION-PLAN, SECTIONS & ELEVATIONS
BRIDGE - PLAN, ELEVATION, & SECTIONS
BRIDGE WING WALLS - PLAN AND ELEVATIONS
ALLS - ELEVATIONS & SECTIONS
DGE- PLAN, ELEVATIONS AND SECTIONS
GE - PLAN, ELEVATION AND SECTIONS
2, & 3 - PLAN AND SECTIONS
T WITH FLAP GATE STA. 18+50L- PLAN, ELEV. AND SECTIONS
DROP STRUCTURE & WINGWALLS - PLAN AND SECTION
DROP STRUCTURE & WINGWALL SECTIONS
ROP STRUCTURE & WINGWALLS - PLAN AND SECTIONS
ROP STRUCTURE & WINGWALL SECTIONS
EWER SIPHON PROFILE AND DETAILS
R SCHEDULE AND DETAILS
R OUTLET - PLAN, ELEVATION AND SECTION
AND LIGHTING PLAN - STATION 0+00 TO 10+00
AND LIGHTING PLAN - STATION 10+00 TO 20+00
AND LIGHTING PLAN - STATION 20+00 TO 30+00
AND LIGHTING PLAN - STATION 30+00 TO 40+00
AND LIGHTING PLAN - STATION 40+00 TO 50+00
AND LIGHTING PLAN - STATION 50+00 TO 60+00
AND LIGHTING PLAN - STATION 60+00 TO 69+00
AND LIGHTING PLAN - STATION 69+00 TO 75+35
AND LIGHTING PLAN - STATION 0+71R TO 7+35R
AND LIGHTING PLAN - STATION 0+00L TO 9+00L
AND LIGHTING PLAN - STATION 9+00L TO 20+63L





SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET, AS INDEXED ON THIS SHEET.

APPROVAL RECOMMENDED BY:

CHIEF ED-D BRANCH

CHIEF ED-GH BRANCH

CHIEF ENGINEERING DIVISION

APPROVED BY:

COL., CORPS OF ENGINEERS

ENGINEERING MANAGER

CHIEF SPECS. & TECH. SUPPORT SECTION

CHIEF GENERAL ENGINEERING SECTION

CHIEF STRUCTURAL SECTION

CHIEF MECH/ELEC/ARCH SECTION

NA

CHIEF HYDRAULICS SECTION

CHIEF HYDROLOGY SECTION

CHIEF GEOTECHNICAL DESIGN SECTION

CHIEF PUBLIC USE PLANNING

SYMBOL DESCRIPT

AE APPROVING OFFICIAL:

ED-D	DESIGNED: KFB/CAS
	CHECKED: GVF
	DRAWN: KFB/CAS
ED-GH	DESIGNED: FWC/DAC
	CHECKED: SVD/MSM

DATE: MAY 92

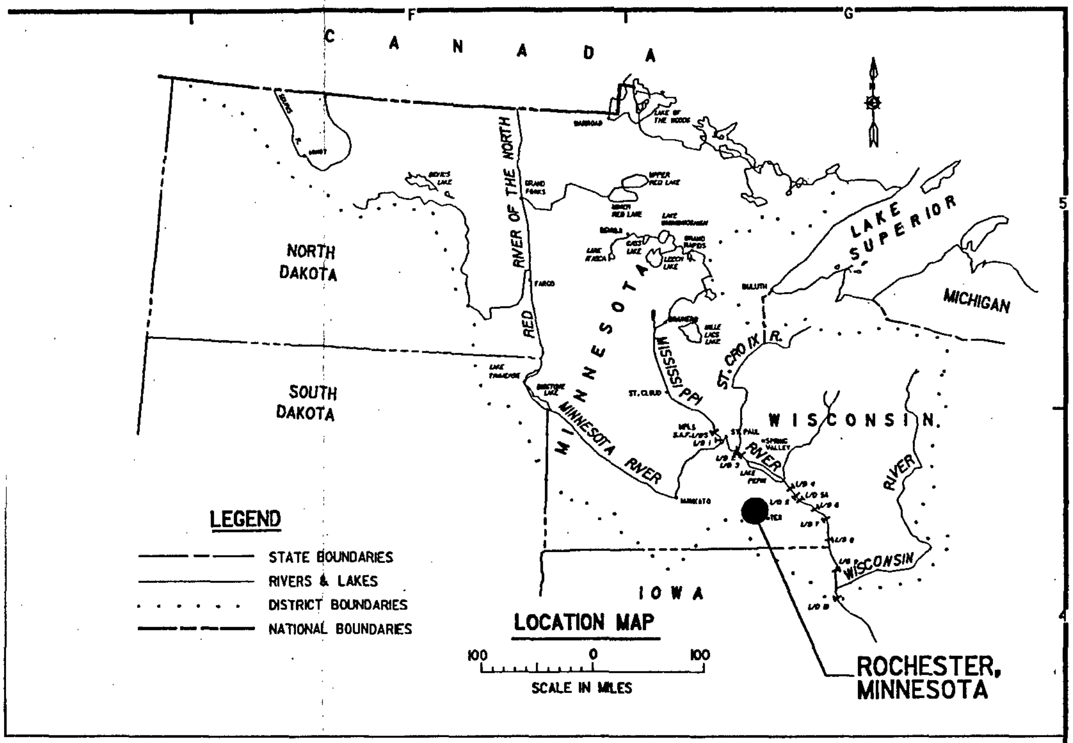
CAD FILE NAME: r4dwgs

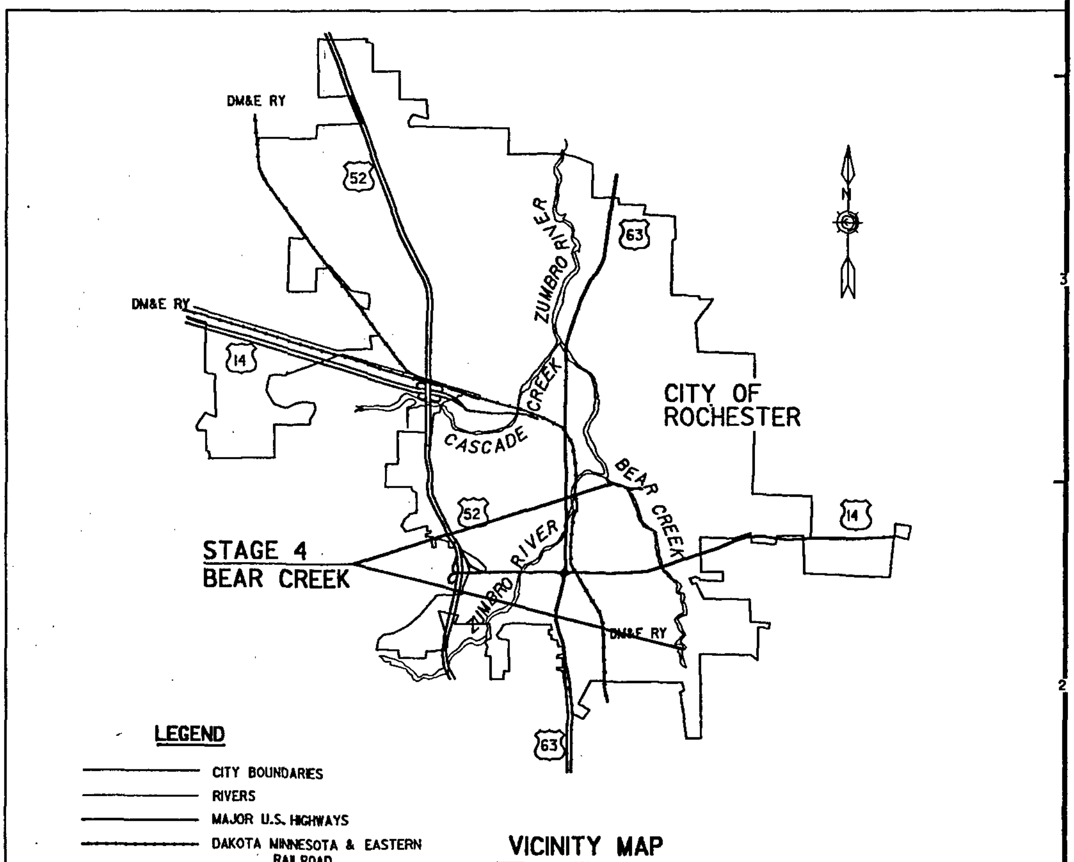
SPEC NO:

FLOOD C

ST

LOC





SYMBOL	DESCRIPTION	DATE	APPROVAL

ENGINEER MANAGER
CHIEF SPECS. & TECH. SUPPORT SECTION
CHIEF GENERAL ENGINEERING SECTION
CHIEF STRUCTURAL SECTION
CHIEF MECH/ELEC/ARCH SECTION
CHIEF HYDRAULICS SECTION
NA
CHIEF HYDROLOGY SECTION
CHIEF GEOTECHNICAL DESIGN SECTION
CHIEF PUBLIC USE PLANNING

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

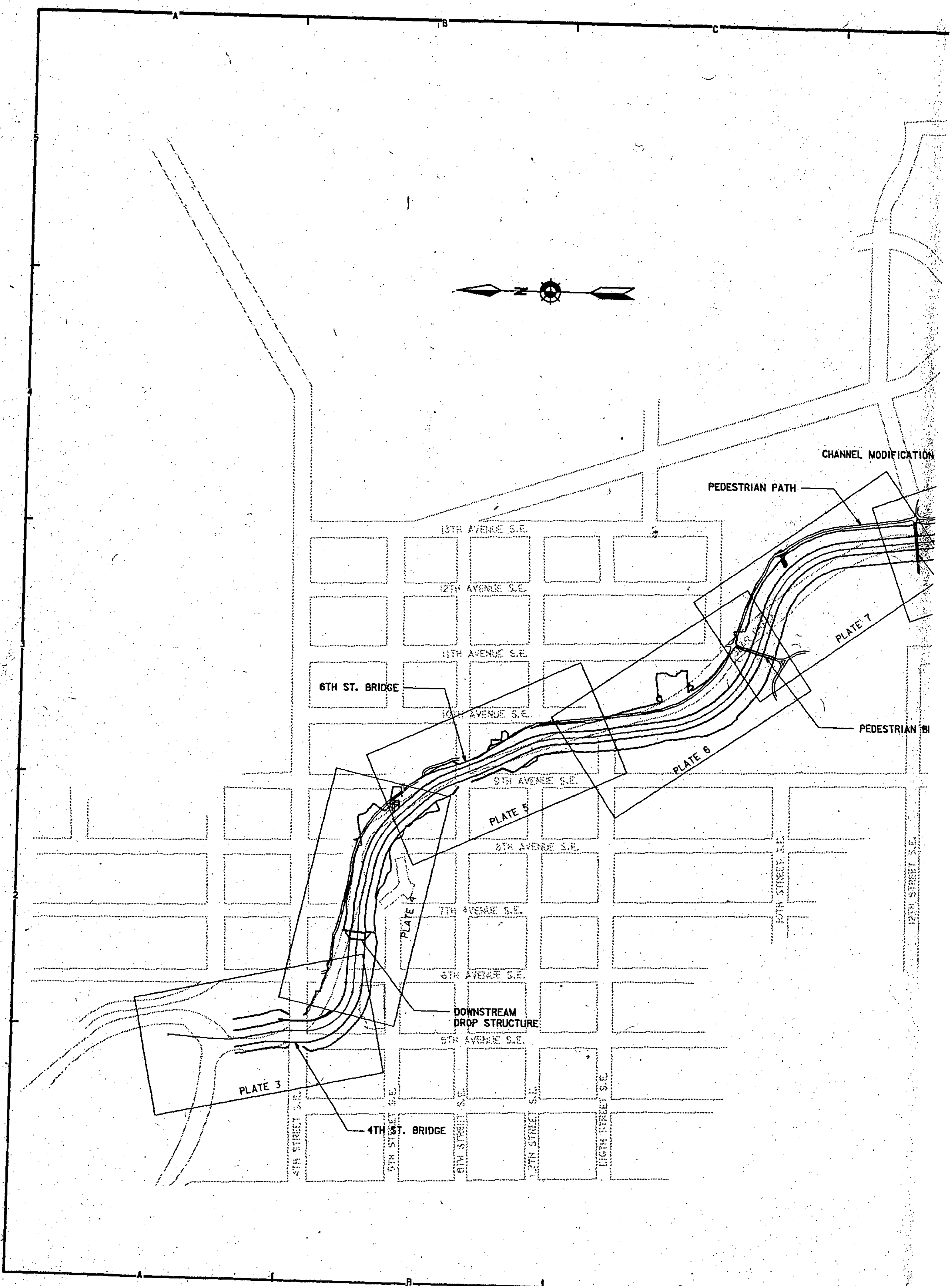
AE APPROVING OFFICIAL:

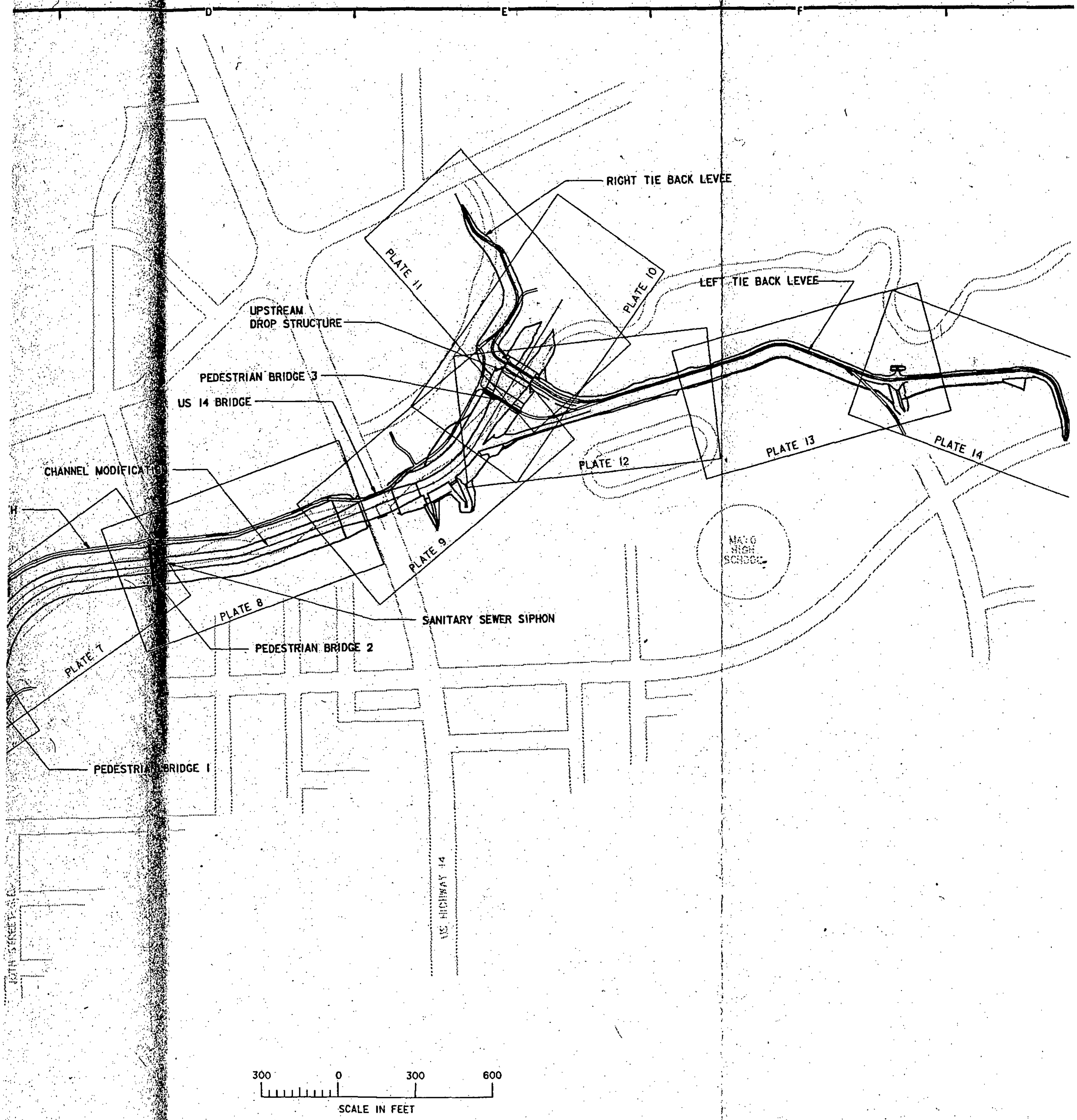
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

STAGE 4 - BEAR CREEK
LOCATION MAP, VICINITY MAP AND DRAWING SCHEDULE

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/CAS
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM
	DATE:	MAY 92

CAD FILE NAME: r4dwgscd.dgn
SPEC NO:
DRAWING NUMBER: PLATE I
SHT 1 OF 53


CHANNEL MODIFICATION
PEDESTRIAN PATH
PEDESTRIAN BI
6TH ST. BRIDGE
13TH AVENUE S.E.
12TH AVENUE S.E.
11TH AVENUE S.E.
10TH AVENUE S.E.
9TH AVENUE S.E.
8TH AVENUE S.E.
7TH AVENUE S.E.
6TH AVENUE S.E.
5TH AVENUE S.E.
PLATE 3
PLATE 4
PLATE 5
PLATE 6
PLATE 7
DOWNSTREAM
DROP STRUCTURE
4TH ST. BRIDGE
4TH STREET S.E.
5TH STREET S.E.
6TH STREET S.E.
12TH STREET S.E.
10TH STREET S.E.



SYMBOL	DESCRIPTION

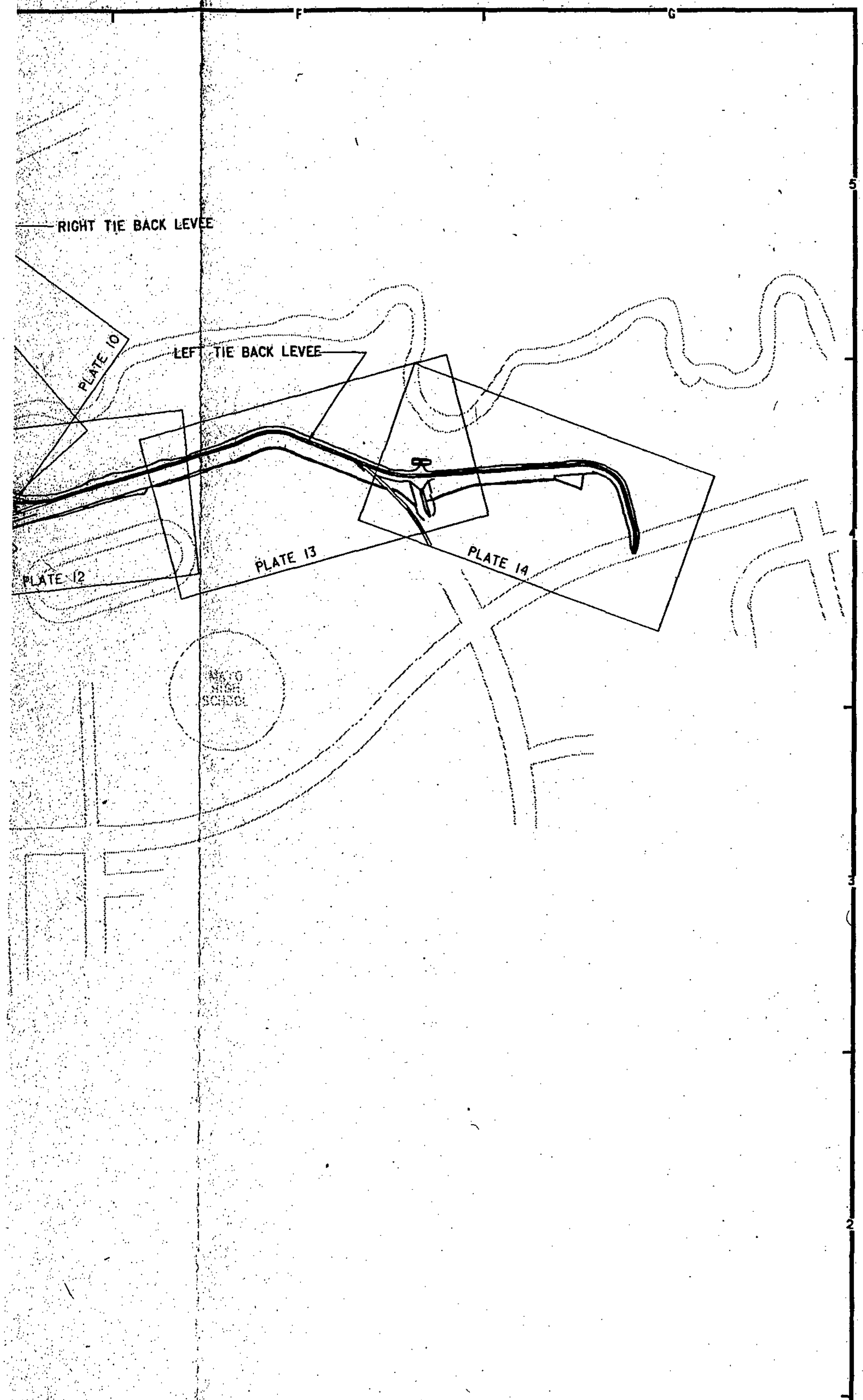
DEP
ST. PAU

AE APPROVING OFFICIAL:

DESIGN MEMORA
FLOOD CONTROL - SOUTH
ROCHESTER,
STAGE 4 -
GENER

DESIGNED: KFB
CHECKED: GVF
DRAWN: KFB/dae
DESIGNED:
CHECKED:
DATE: MAY 92

CAD FILE NAME: r4genpln.dgn
SPEC NO:



SYMBOL	DESCRIPTION	DATE	APPROVAL

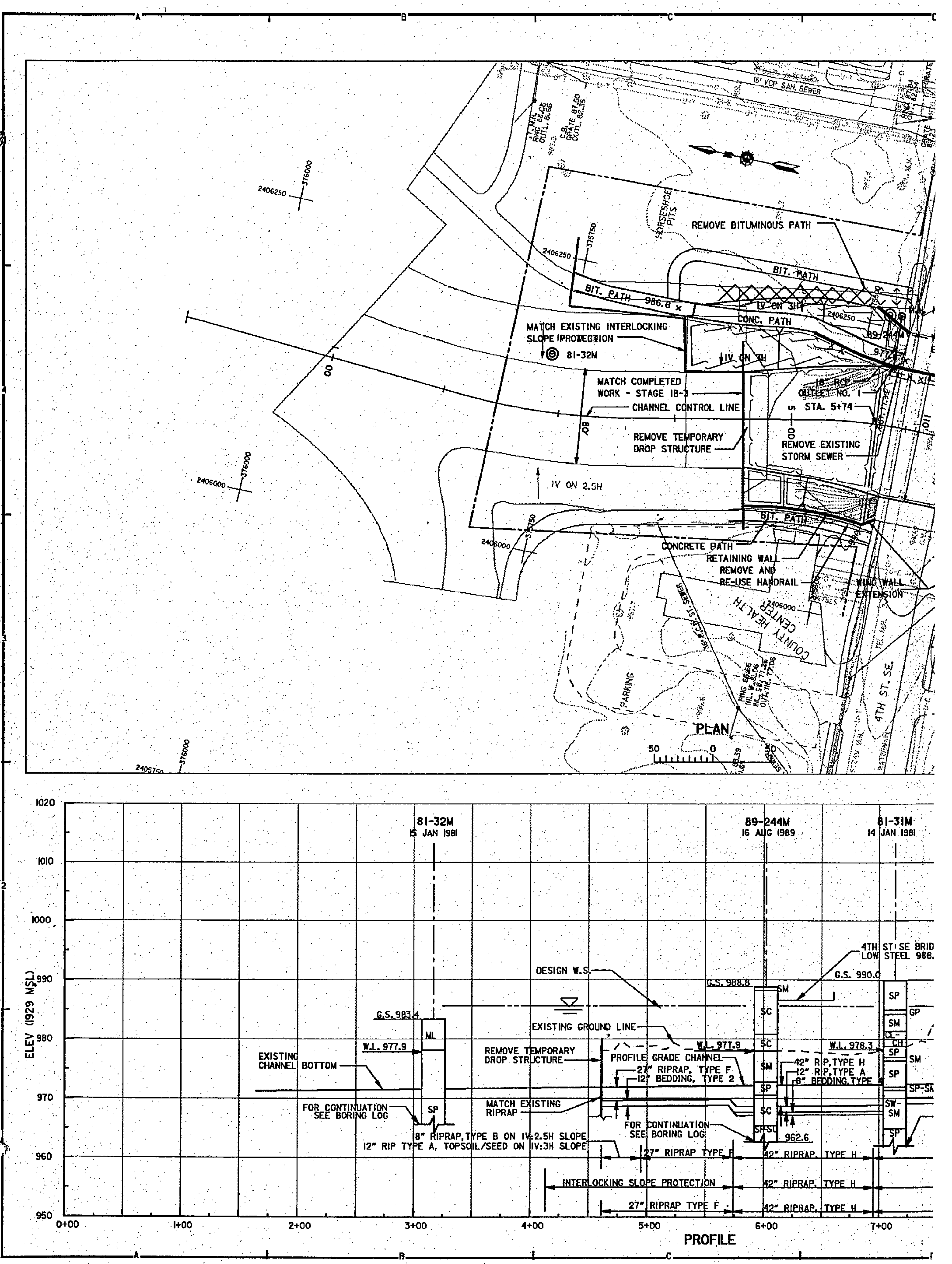
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

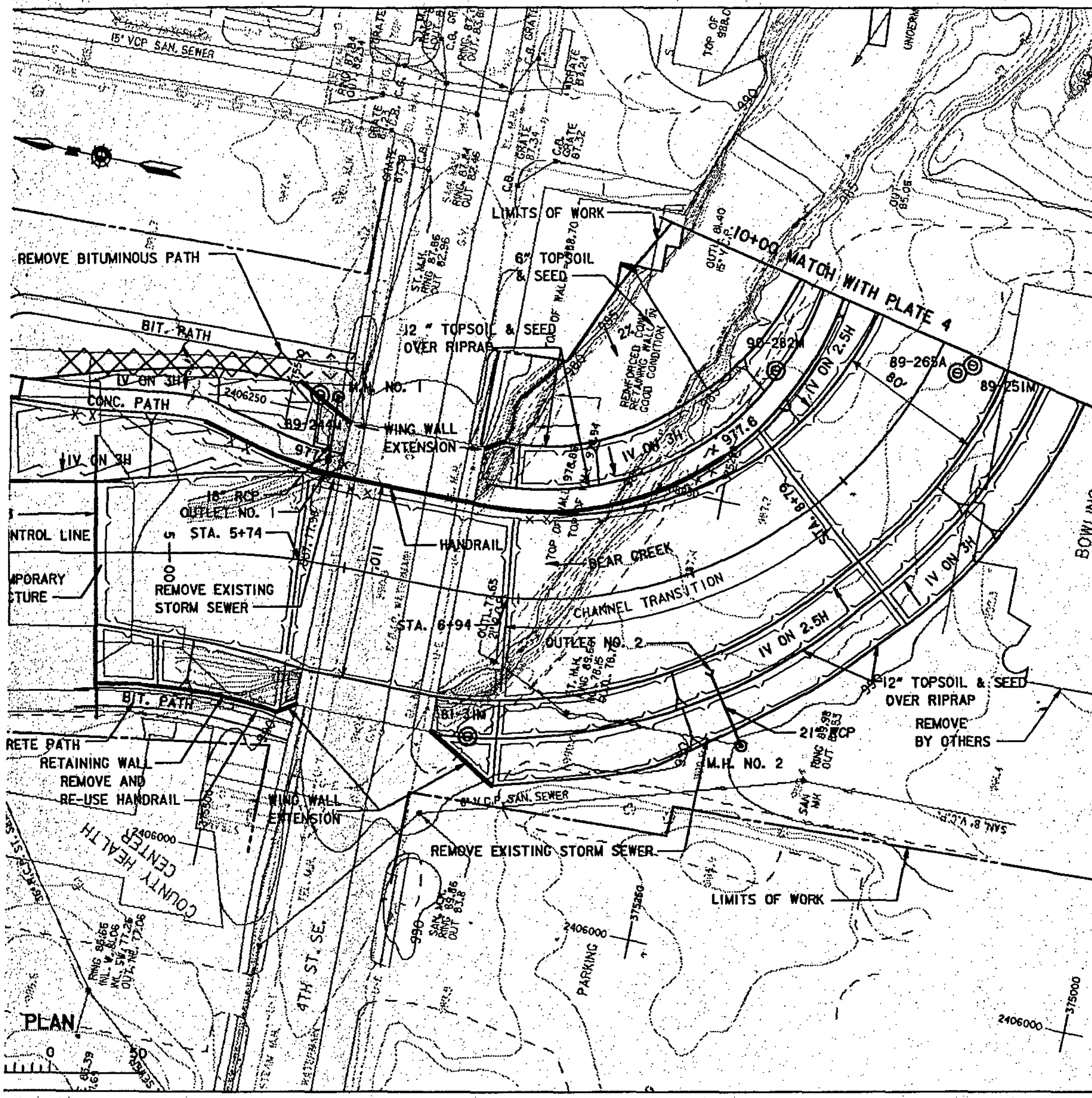
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
GENERAL PLAN

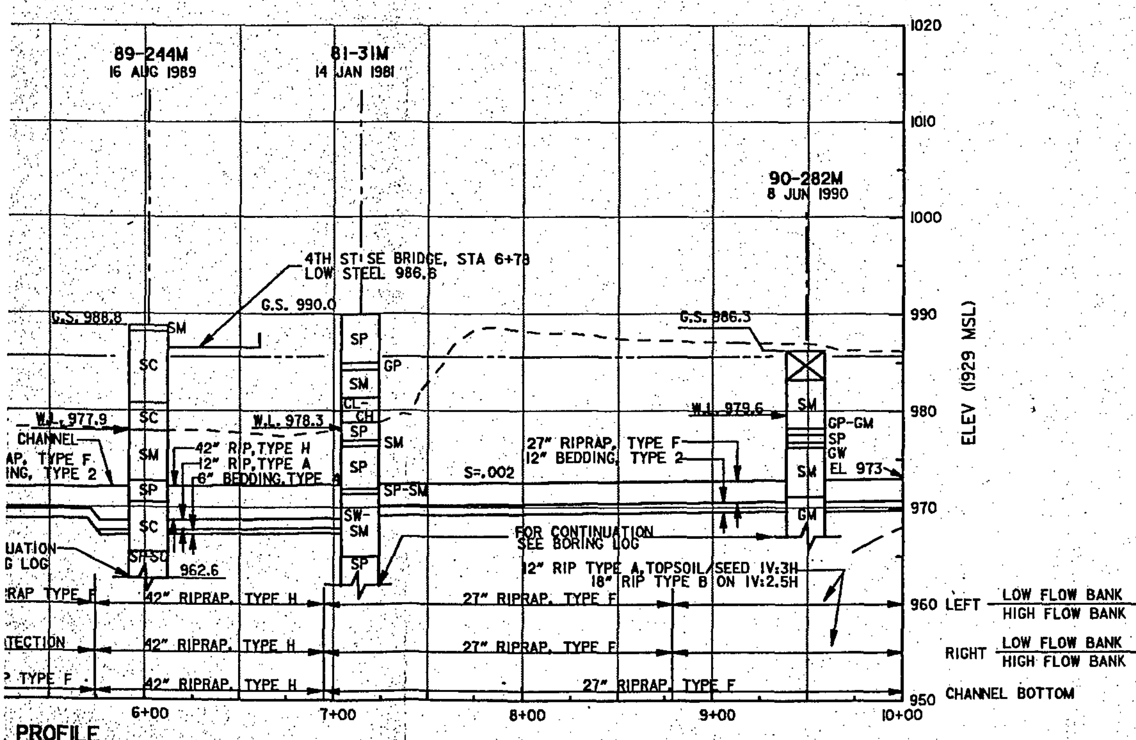
ED-D DESIGNED:	KFB
ED-D CHECKED:	GVF
ED-D DRAWN:	KFB/dae
ED-GH DESIGNED:	
ED-GH CHECKED:	
DATE:	MAY 92

CAD FILE NAME: r4genpln.dgn
SPEC NO:
DRAWING NUMBER: PLATE 2
SHT 2 OF 53



REMOVE BITUMINOUS PATH
BIT. PATH
MATCH EXISTING INTERLOCKING SLOPE PROTECTION
81-32M
MATCH COMPLETED WORK - STAGE IB-3
CHANNEL CONTROL LINE
REMOVE TEMPORARY DROP STRUCTURE
18" RCP OUTLET NO. 1
STA. 5+74
REMOVE EXISTING STORM SEWER
1V ON 2.5H
1V ON 3H
CONC. PATH
CONCRETE PATH
RETAINING WALL
REMOVE AND RE-USE HANDRAIL
WING WALL EXTENSION
COUNTY HEALTH CENTER
PARKING
4TH ST. SE.
HORSESHOE PITS
15" VCP SAN. SEWER
PLAN
81-32M
15 JAN 1981
89-244M
16 AUG 1989
81-31M
14 JAN 1981
4TH ST SE BRID
LOW STEEL 986.
DESIGN W.S.
G.S. 988.8
G.S. 990.0
G.S. 983.4
EXISTING GROUND LINE
W.L. 977.9
W.L. 978.3
EXISTING CHANNEL BOTTOM
REMOVE TEMPORARY DROP STRUCTURE
PROFILE GRADE CHANNEL
27" RIPRAP, TYPE F
12" BEDDING, TYPE 2
42" RIP, TYPE H
12" RIP, TYPE A
6" BEDDING, TYPE
FOR CONTINUATION SEE BORING LOG
MATCH EXISTING RIPRAP
18" RIPRAP, TYPE B ON 1V:2.5H SLOPE
12" RIP TYPE A, TOPSOIL/SEED ON 1V:3H SLOPE
962.6
27" RIPRAP TYPE F
42" RIPRAP, TYPE H
INTERLOCKING SLOPE PROTECTION
ELEV (1929 MSL)
PROFILE





REFERENCES:

1. CHANNEL SECTIONS
2. STORM SEWER SCHEDULE AND OUTLETS
6. 4TH STREET SE UNDERPASS
4. LANDSCAPE AND LIGHTING PLAN

SYMBOL	DESCRI

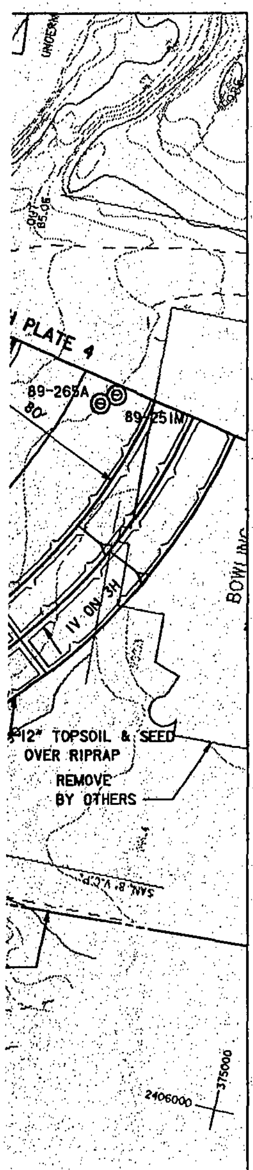
AE APPROVING OFFICIAL:

FLOOD CO

S

S

ED-D	DESIGNED: KFB/CAS	
	CHECKED: GVF	
	DRAWN: KFB/dae	
ED-GH	DESIGNED: FWC/DAC	
	CHECKED: SVD/MSM	CAD FILE NAME: r4lol.
DATE: MAY 92		SPEC NO:



ELEV (1929 MSL)

LEFT LOW FLOW BANK / HIGH FLOW BANK
RIGHT LOW FLOW BANK / HIGH FLOW BANK
CHANNEL BOTTOM

REFERENCES: **PLATE NO.**

1. CHANNEL SECTIONS	15-16
2. STORM SEWER SCHEDULE AND OUTLETS	41-42
6. 4TH STREET SE UNDERPASS	28
4. LANDSCAPE AND LIGHTING PLAN	43

SYMBOL	DESCRIPTION	DATE	APPROVAL

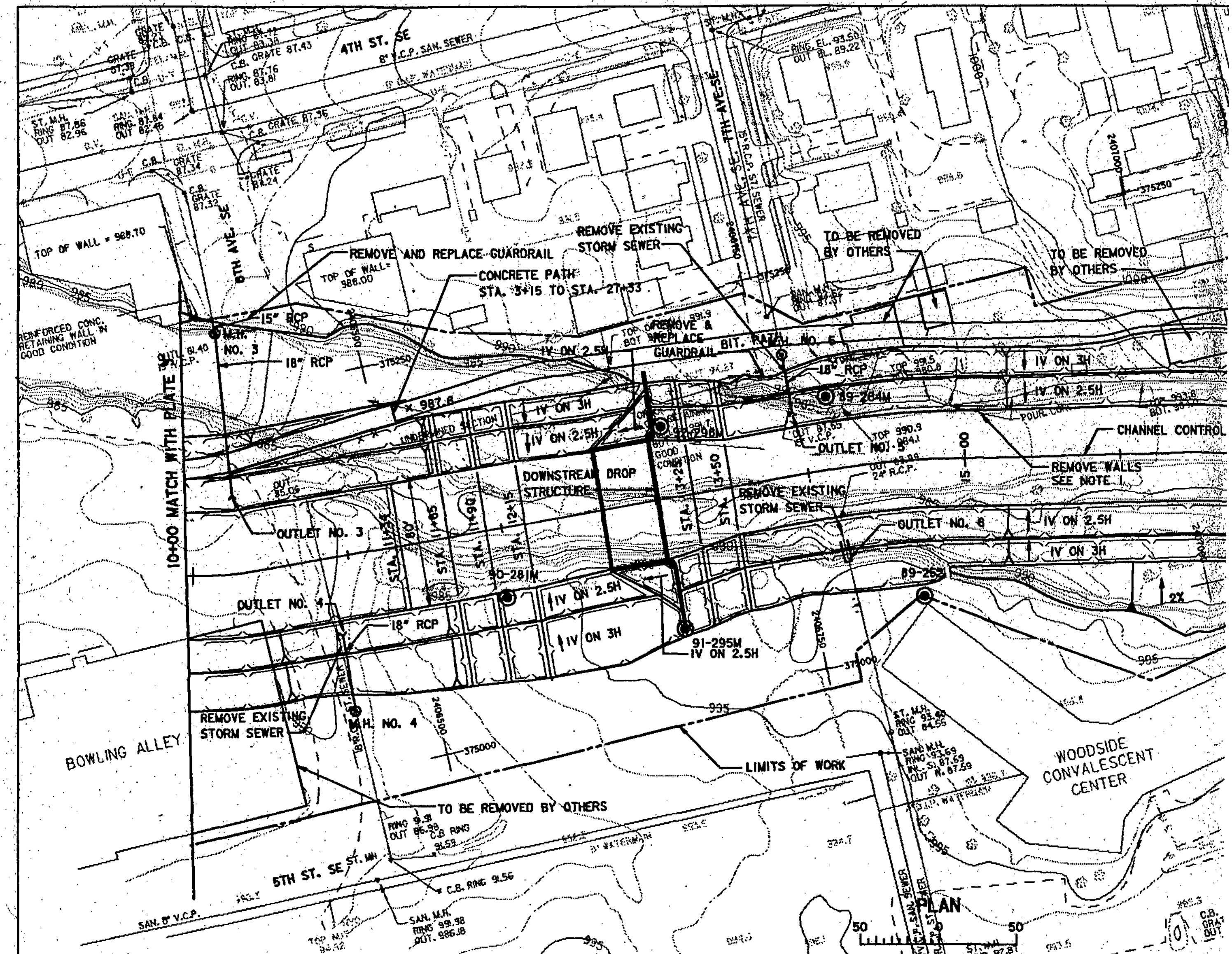
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

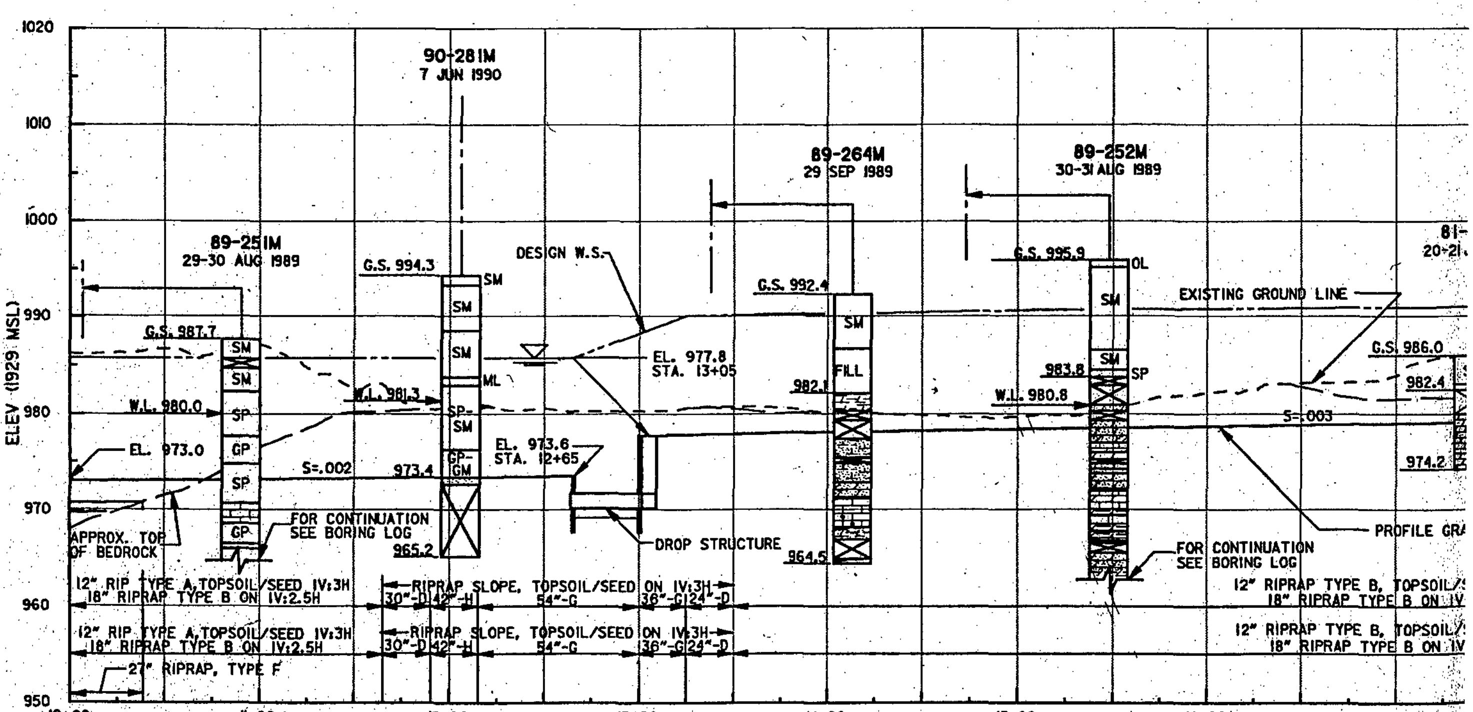
AE APPROVING OFFICIAL:

ED-D DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: KFB/dae
ED-GH DESIGNED: FWC/DAC
CHECKED: SVD/MSM
DATE: MAY 92

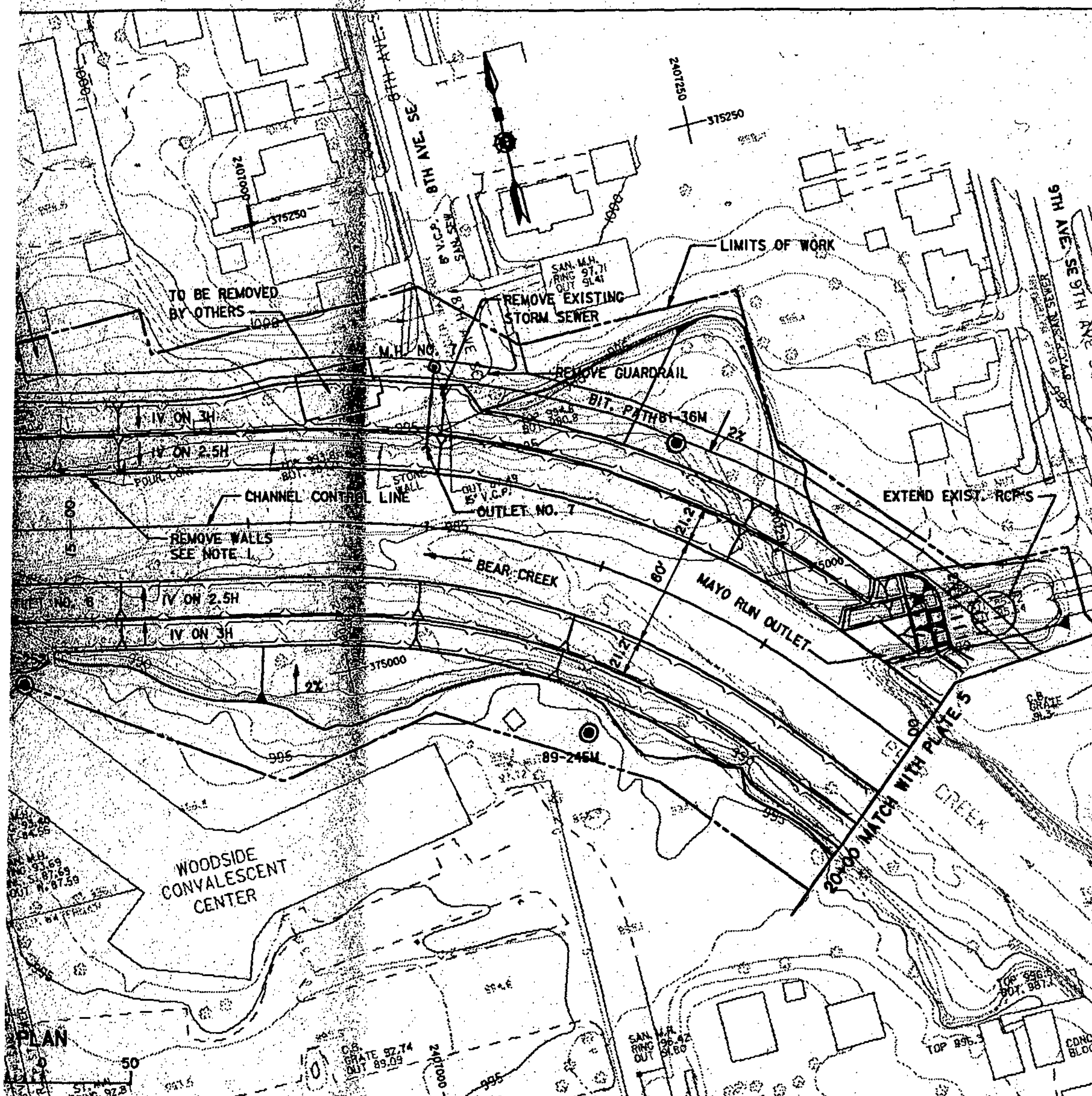
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 00+00 TO 10+00

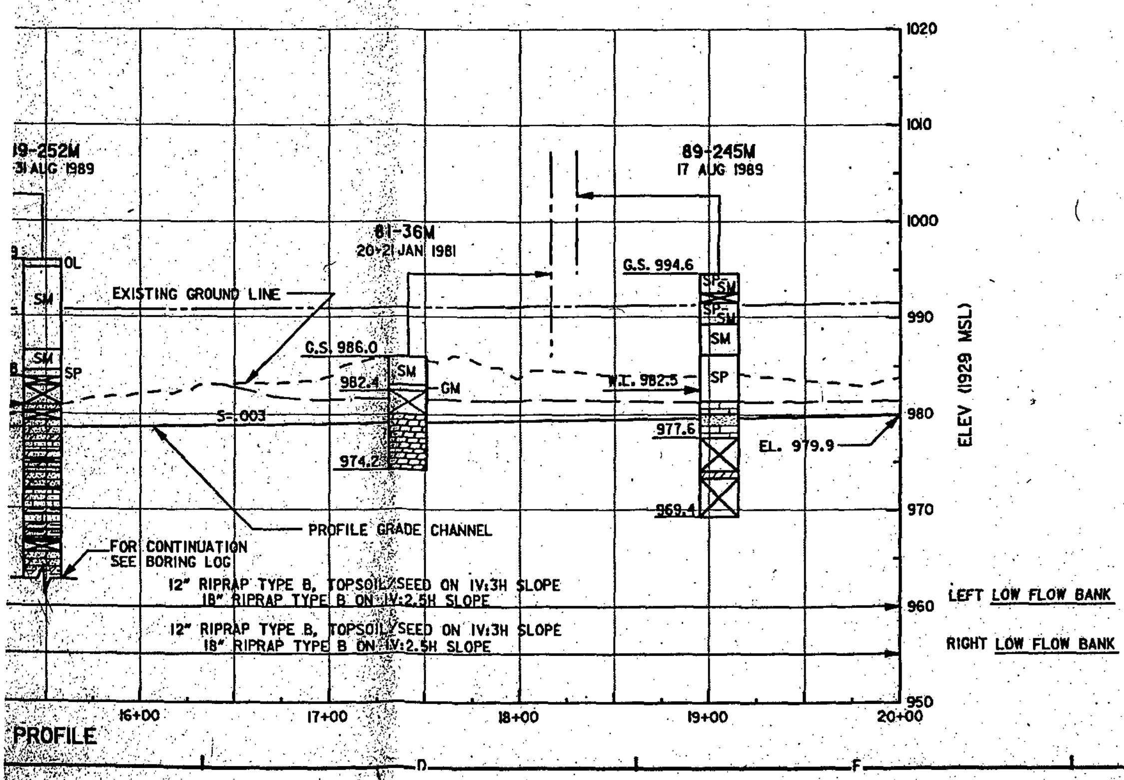
CAD FILE NAME: r4lol.dgn
SPEC NO:
DRAWING NUMBER: PLATE 3
SHT 3 OF 53


4TH ST. SE
8" V.C.P. SAN. SEWER
8TH AVE. SE
7TH AVE. SE
TOP OF WALL = 988.70
TOP OF WALL= 986.00
REINFORCED CONC. RETAINING WALL IN GOOD CONDITION
REMOVE AND REPLACE GUARDRAIL
REMOVE EXISTING STORM SEWER
CONCRETE PATH STA. 3+15 TO STA. 27+33
TO BE REMOVED BY OTHERS
M.H. NO. 3
15" RCP
18" RCP
REMOVE & REPLACE GUARDRAIL
BIT. PATH
M.H. NO. 5
89-264M
1V ON 3H
1V ON 2.5H
CHANNEL CONTROL
REMOVE WALLS SEE NOTE 1
OUTLET NO. 5
DOWNSTREAM DROP STRUCTURE
10+00 MATCH WITH PLATE
OUTLET NO. 3
OUTLET NO. 6
90-281M
89-252M
OUTLET NO. 4
91-295M
1V ON 2.5H
REMOVE EXISTING STORM SEWER
M.H. NO. 4
BOWLING ALLEY
LIMITS OF WORK
TO BE REMOVED BY OTHERS
WOODSIDE CONVALESCENT CENTER
5TH ST. SE
SAN. 8" V.C.P.
PLAN
50
50


ELEV (1929 MSL)
1020
1010
1000
990
980
970
960
950
90-281M
7 JUN 1990
89-264M
29 SEP 1989
89-252M
30-31 AUG 1989
89-251M
29-30 AUG 1989
G.S. 994.3
G.S. 987.7
G.S. 992.4
G.S. 995.9
G.S. 986.0
DESIGN W.S.
EL. 977.8
STA. 13+05
EL. 973.6
STA. 12+65
W.L. 980.0
W.L. 981.3
W.L. 980.8
EL. 973.0
S=.002
S=.003
973.4
965.2
982.1
964.5
983.8
982.4
974.2
EXISTING GROUND LINE
APPROX. TOP OF BEDROCK
FOR CONTINUATION SEE BORING LOG
DROP STRUCTURE
PROFILE GRADE
12" RIP TYPE A, TOPSOIL/SEED 1V:3H
18" RIPRAP TYPE B ON 1V:2.5H
RIPRAP SLOPE, TOPSOIL/SEED ON 1V:3H
30"-D 42"-H 54"-G 36"-G 24"-D
27" RIPRAP, TYPE F
12" RIPRAP TYPE B, TOPSOIL/
18" RIPRAP TYPE B ON 1V
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00

PROFILE





NOTES:

1. REMOVE ALL CONCRETE AND STONE WALL BETWEENN STA. 12+00 AND 18+00

REFERENCES:

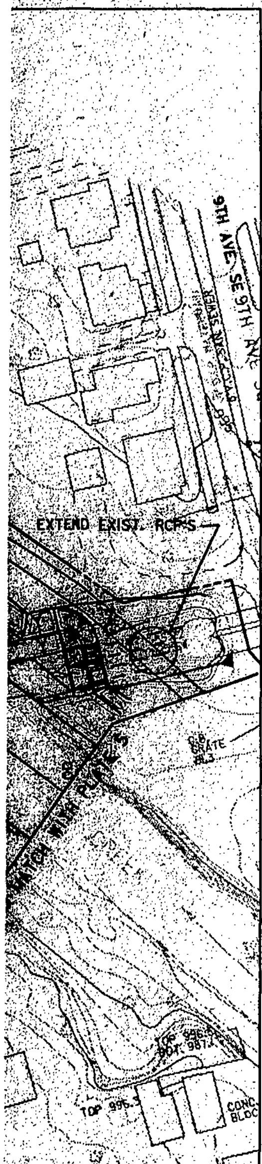
1. CHANNEL SECTIONS
2. DOWNSTREAM DROP STRUCTURE AND WIN
3. STORM SEWER SCHEDULE & OUTLETS
4. LANDSCAPE AND LIGHTING PLAN

SYMBOL	DESCRIP

AE APPROVING OFFICIAL:

FLOOD CO

DESIGNED: KFB/CAS	
CHECKED: GVF	
DRAWN: CAS/dae	
DESIGNED: FWC/DAC	
CHECKED: SVD/MSM	CAD FILE NAME: r4lo2.
DATE: MAY 92	SPEC NO:



ELEV (1929 MSL)

LEFT LOW FLOW BANK

RIGHT LOW FLOW BANK

NOTES:

1. REMOVE ALL CONCRETE AND STONE WALLS ON RIGHT BANK BETWEENN STA. 12+00 AND 18+00

REFERENCES:

REFERENCES:	PLATE NO.
1. CHANNEL SECTIONS	16-19
2. DOWNSTREAM DROP STRUCTURE AND WINGWALLS	36-37
3. STORM SEWER SCHEDULE & OUTLETS	41-42
4. LANDSCAPE AND LIGHTING PLAN	44

SYMBOL	DESCRIPTION	DATE	APPROVAL

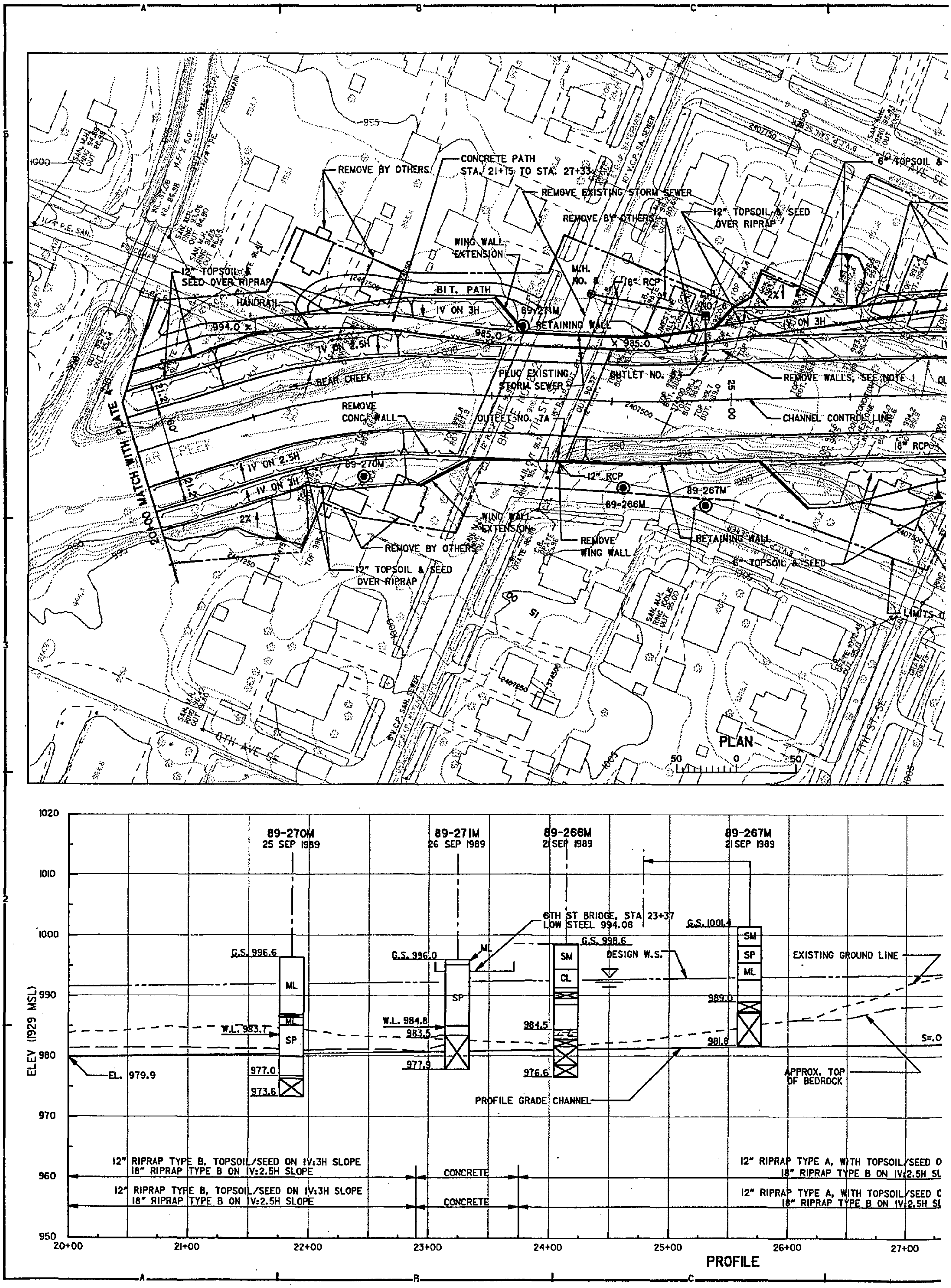
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

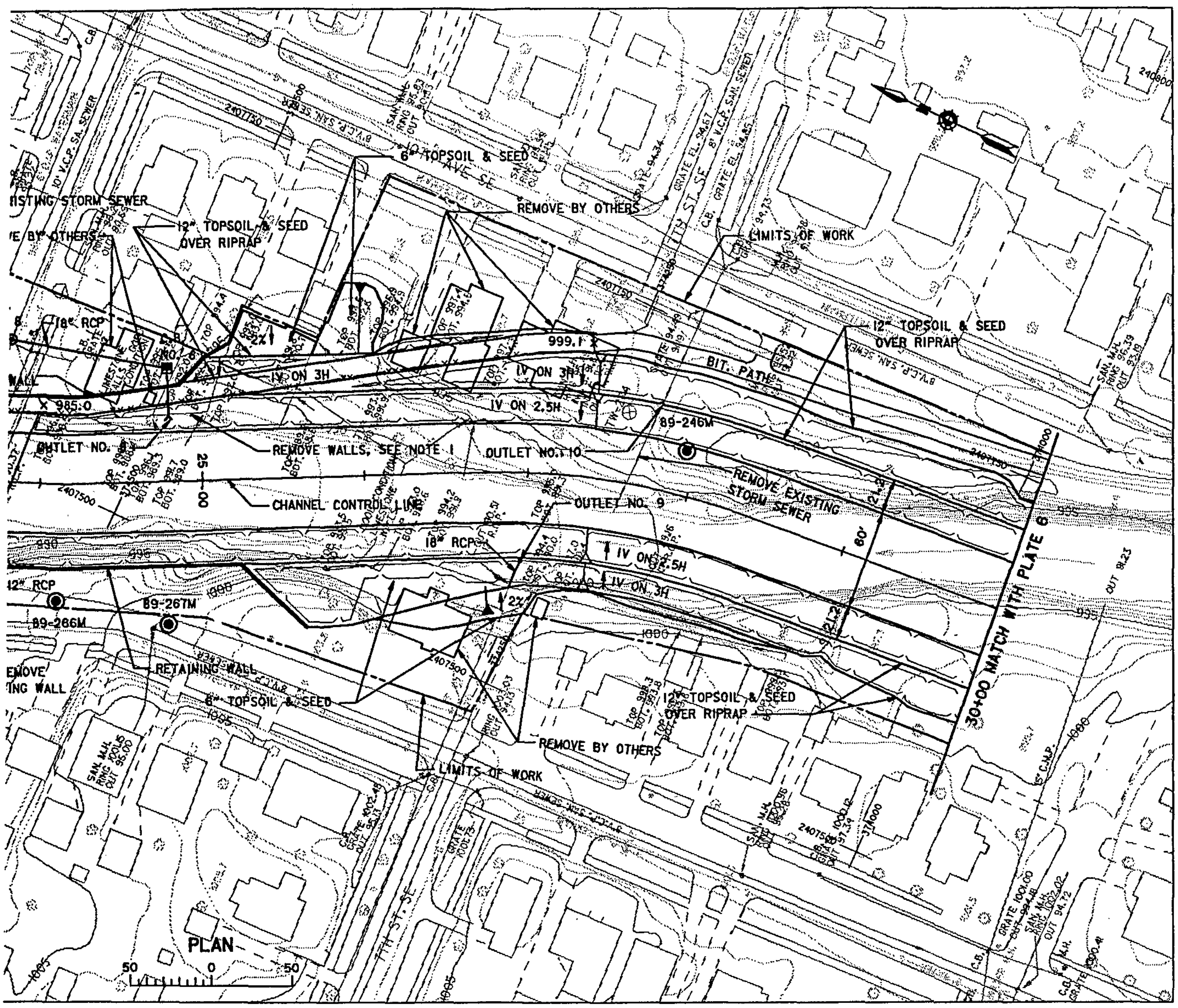
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 10+00 TO 20+00

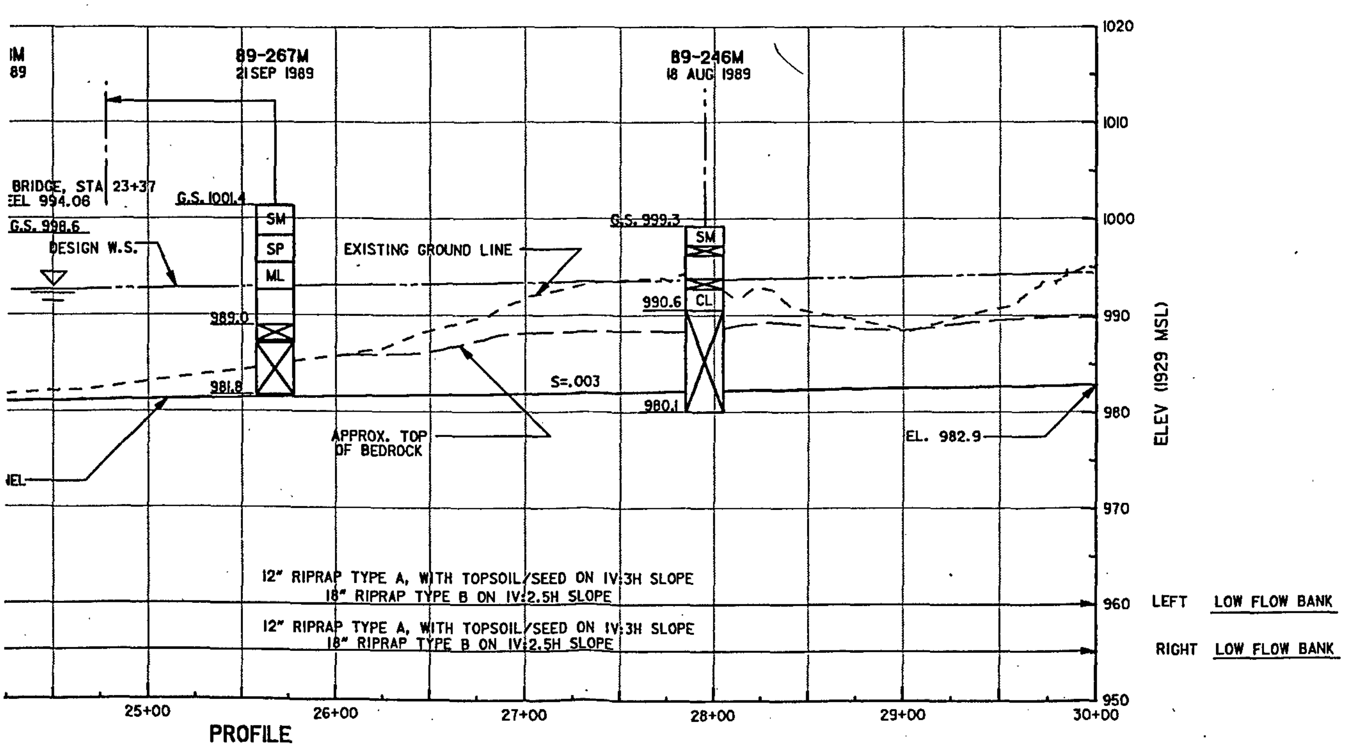
DESIGNED:	KFB/CAS
CHECKED:	GVF
DRAWN:	CAS/dae
DESIGNED:	FWC/DAC
CHECKED:	SVD/MSM
DATE:	MAY 92

CAD FILE NAME: r4lo2.dgn
SPEC NO:
DRAWING NUMBER: PLATE 4
SHT 4 OF 53



REMOVE BY OTHERS
CONCRETE PATH STA. 21+15 TO STA. 27+33
REMOVE EXISTING STORM SEWER
REMOVE BY OTHERS
12" TOPSOIL & SEED OVER RIPRAP
6" TOPSOIL &
WING WALL EXTENSION
M.H. NO. 8
18" RCP
12" TOPSOIL & SEED OVER RIPRAP
HANDRAIL
BIT. PATH
1V ON 3H
89-271M
RETAINING WALL
994.0
985.0
985.0
1V ON 3H
1V ON 2.5H
BEAR CREEK
PLUG EXISTING STORM SEWER
OUTLET NO. 8
REMOVE WALLS, SEE NOTE 1
REMOVE CONC. WALL
OUTLET NO. 7A
25+00
CHANNEL CONTROL LINE
18" RCP
20+00 MATCH WITH PLATE
1V ON 2.5H
89-270M
1V ON 3H
12" RCP
89-266M
89-267M
WING WALL EXTENSION
REMOVE WING WALL
RETAINING WALL
REMOVE BY OTHERS
6" TOPSOIL & SEED
12" TOPSOIL & SEED OVER RIPRAP
LIMITS O
6TH AVE SE
7TH ST SE
BRIDGE NO.
6TH ST
PLAN
50 0 50
89-270M 25 SEP 1989
89-271M 26 SEP 1989
89-266M 21 SEP 1989
89-267M 21 SEP 1989
6TH ST BRIDGE, STA 23+37 LOW STEEL 994.06
G.S. 996.6
G.S. 996.0
G.S. 998.6
G.S. 1001.4
DESIGN W.S.
EXISTING GROUND LINE
ML
SP
SM
CL
W.L. 983.7
W.L. 984.8
983.5
984.5
989.0
981.8
977.0
973.6
977.9
976.6
EL. 979.9
S=0.
APPROX. TOP OF BEDROCK
PROFILE GRADE CHANNEL
ELEV (1929 MSL)
1020
1010
1000
990
980
970
960
950
12" RIPRAP TYPE B, TOPSOIL/SEED ON 1V:3H SLOPE
18" RIPRAP TYPE B ON 1V:2.5H SLOPE
CONCRETE
12" RIPRAP TYPE B, TOPSOIL/SEED ON 1V:3H SLOPE
18" RIPRAP TYPE B ON 1V:2.5H SLOPE
CONCRETE
12" RIPRAP TYPE A, WITH TOPSOIL/SEED O
18" RIPRAP TYPE B ON 1V:2.5H SL
12" RIPRAP TYPE A, WITH TOPSOIL/SEED C
18" RIPRAP TYPE B ON 1V:2.5H SL
20+00
21+00
22+00
23+00
24+00
25+00
26+00
27+00
PROFILE





NOTES:

1. REMOVE STO
   EXCEPTION IS

REFERENCES:

1. CHANNEL SEC
2. 6TH STREET
3. RETAINING W
4. STORM SEWE
5. LANDSCAPE

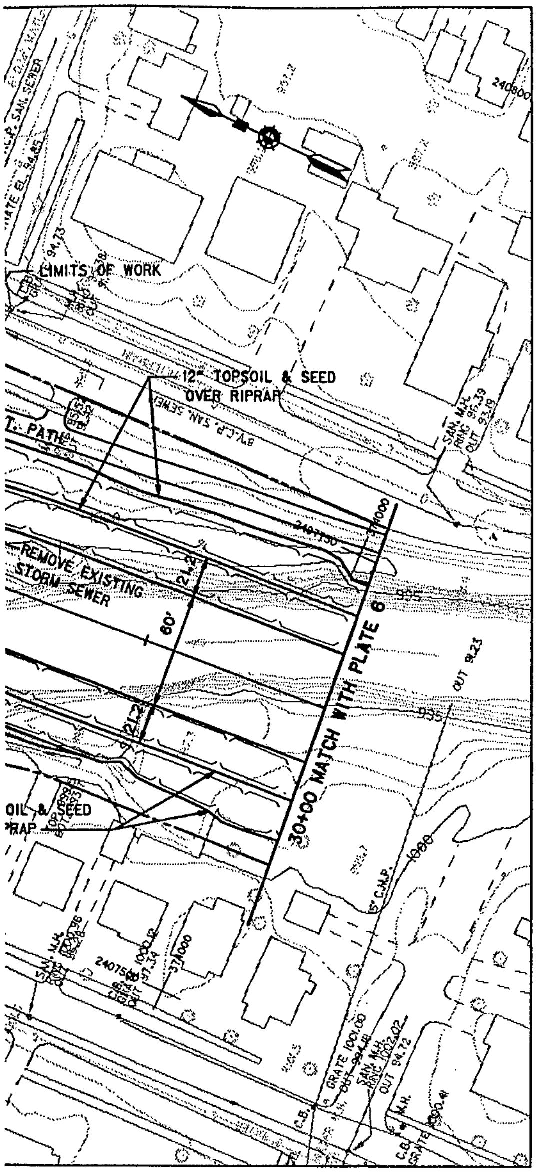
SYMBOL

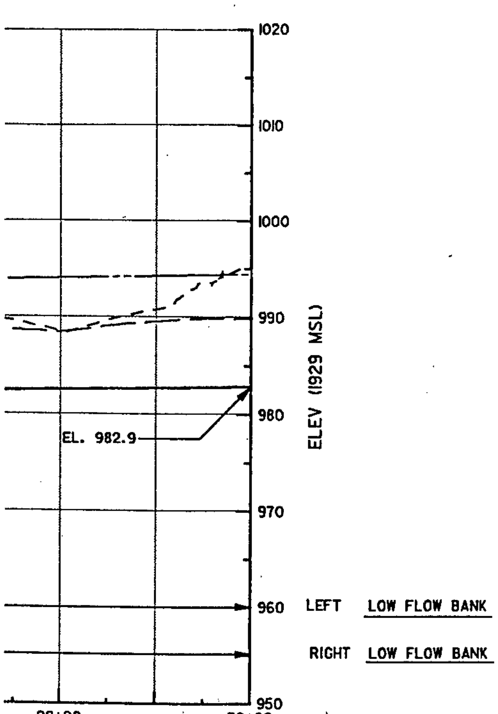
AE APPROVING OFFIC

ED-D DESIGNED: KFB/
CHECKED: GVF
DRAWN: CAS/

ED-GH DESIGNED: FWC/
CHECKED: SVD/

DATE: MAY 92





NOTES:

1. REMOVE STONE WALLS ON RIGHT BANK BETWEEN STA. 24+00 AND 28+00. EXCEPTION IS FAR WEST WALL IN RESIDENTIAL YARD AT STA. 25+50 RIGHT BANK.

REFERENCES:

REFERENCES	PLATE NO.
1. CHANNEL SECTIONS	18-20
2. 6TH STREET BRIDGE	29-30
3. RETAINING WALLS	31
4. STORM SEWER SCHEDULE AND OUTLETS	41-42
5. LANDSCAPE AND LIGHTING PLAN	45

SYMBOL	DESCRIPTION	DATE	APPROVAL

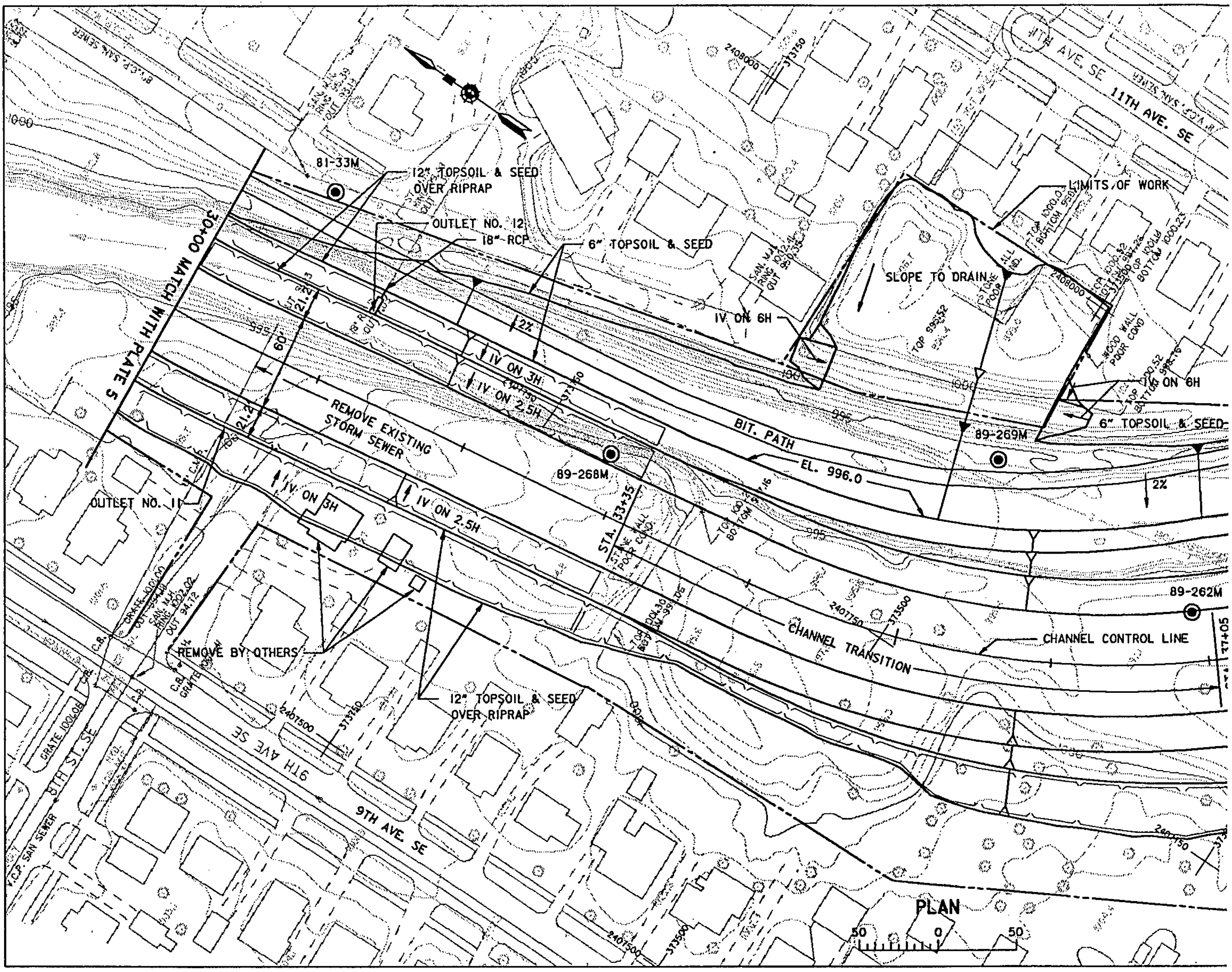
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

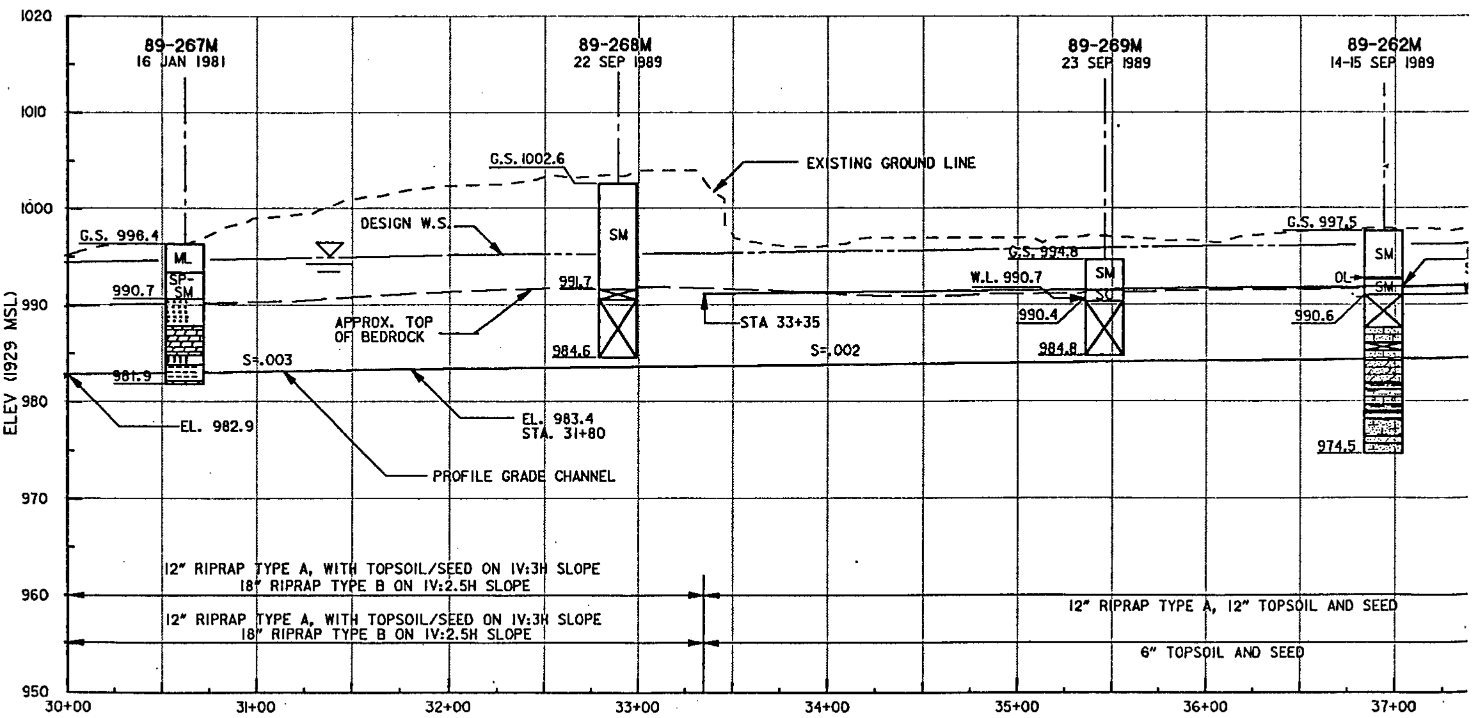
AE APPROVING OFFICIAL:

ED-D: DESIGNED: KFB/CAS; CHECKED: GVF; DRAWN: CAS/dae
ED-GH: DESIGNED: FWC/DAC; CHECKED: SVD/MSM
DATE: MAY 92

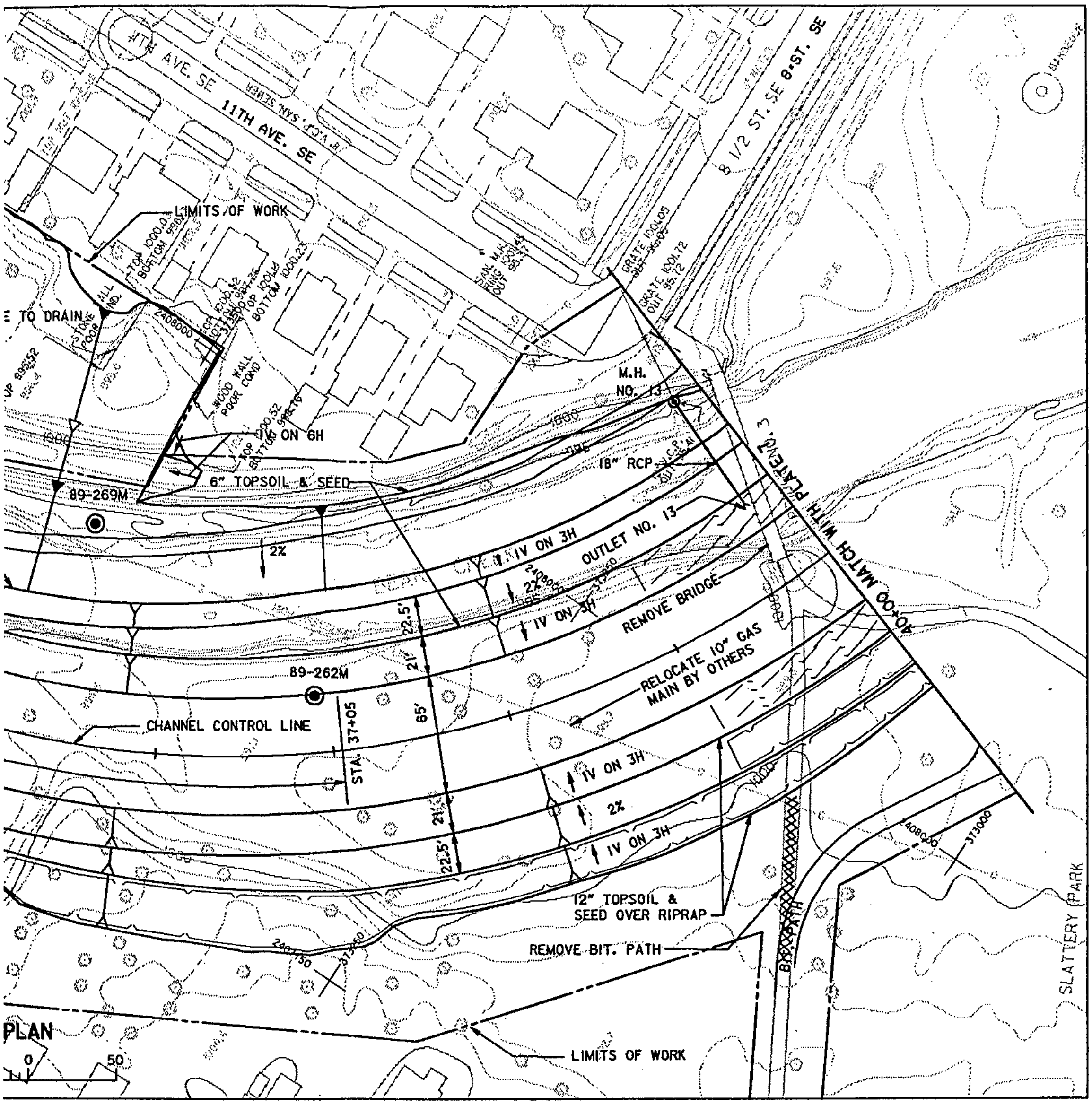
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 20+00 TO 30+00

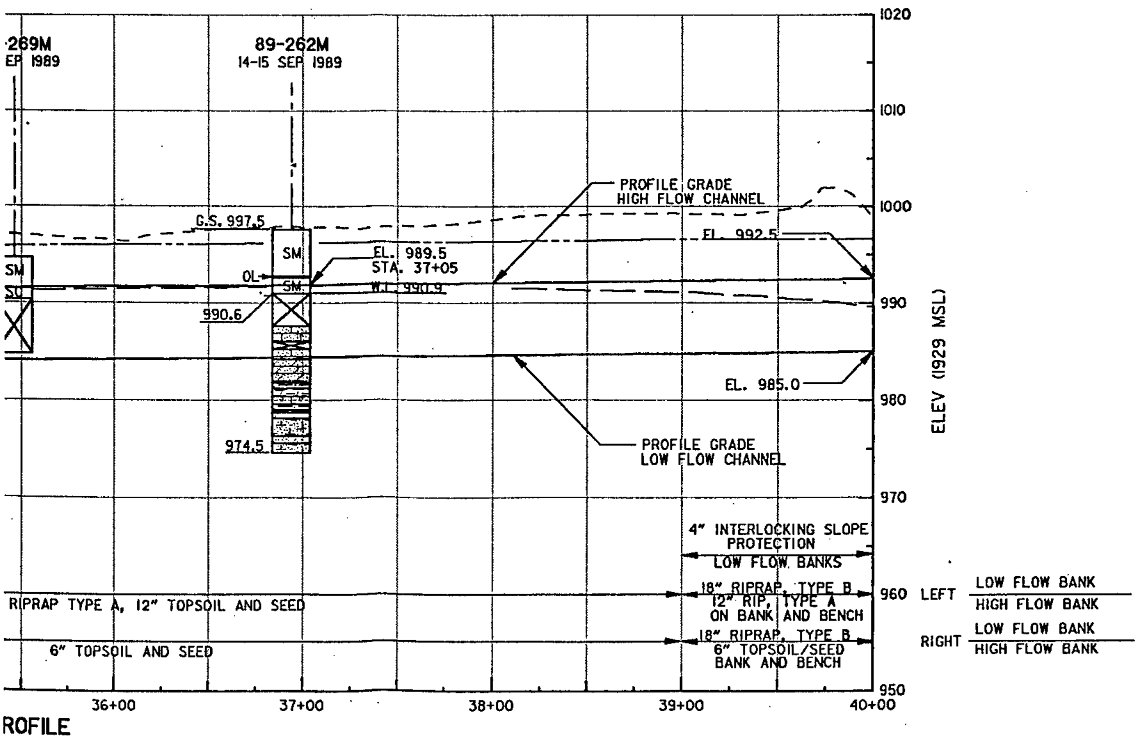
CAD FILE NAME: r4lo3.dgn
SPEC NO:
DRAWING NUMBER: PLATE 5
SHT 5 OF 53


81-33M
12" TOPSOIL & SEED OVER RIPRAP
OUTLET NO. 12
18" RCP
6" TOPSOIL & SEED
30+00 MATCH WITH PLATE 5
LIMITS OF WORK
SLOPE TO DRAIN
1V ON 6H
1V ON 3H
1V ON 2.5H
60'
2%
REMOVE EXISTING STORM SEWER
BIT. PATH
EL. 996.0
89-269M
89-268M
89-262M
STA. 33+35
OUTLET NO. 11
REMOVE BY OTHERS
12" TOPSOIL & SEED OVER RIPRAP
CHANNEL TRANSITION
CHANNEL CONTROL LINE
37+05
9TH AVE SE
9TH AVE. SE
8TH ST. SE
11TH AVE. SE
PLAN
50
0
50


89-267M
16 JAN 1981
89-268M
22 SEP 1989
89-269M
23 SEP 1989
89-262M
14-15 SEP 1989
G.S. 1002.6
EXISTING GROUND LINE
G.S. 996.4
DESIGN W.S.
G.S. 994.8
G.S. 997.5
ML
SP-SM
SM
SC
OL
990.7
991.7
W.L. 990.7
990.4
990.6
APPROX. TOP OF BEDROCK
STA 33+35
984.6
984.8
S=.003
S=.002
981.9
EL. 982.9
EL. 983.4
STA. 31+80
974.5
PROFILE GRADE CHANNEL
ELEV (1929 MSL)
1020
1010
1000
990
980
970
960
950
12" RIPRAP TYPE A, WITH TOPSOIL/SEED ON 1V:3H SLOPE
18" RIPRAP TYPE B ON 1V:2.5H SLOPE
12" RIPRAP TYPE A, WITH TOPSOIL/SEED ON 1V:3H SLOPE
18" RIPRAP TYPE B ON 1V:2.5H SLOPE
12" RIPRAP TYPE A, 12" TOPSOIL AND SEED
6" TOPSOIL AND SEED
30+00
31+00
32+00
33+00
34+00
35+00
36+00
37+00

PROFILE





NOTES:

1. THE PROFILE GRADE HIGH FLOW CHANNEL IS FLOW AND HIGH FLOW CHANNELS.

REFERENCES:

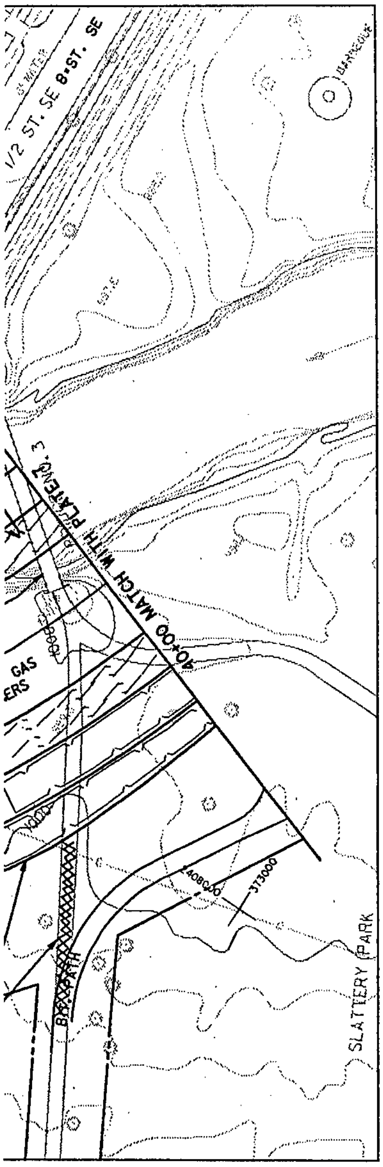
1. CHANNEL SECTIONS
2. STORM SEWER SCHEDULE AND OUTLETS
3. LANDSCAPE AND LIGHTING PLAN

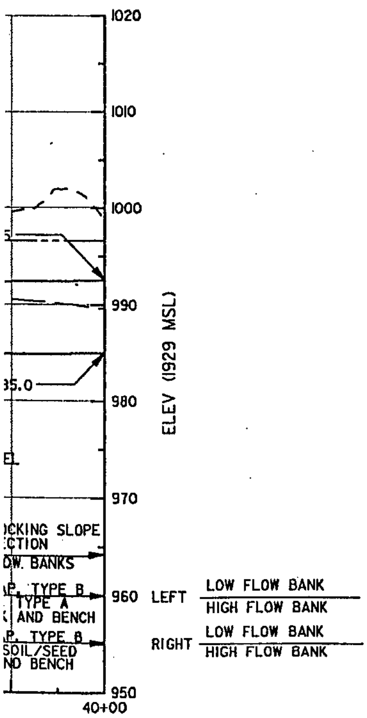
SYMBOL	DESCRIPTIO

AE APPROVING OFFICIAL:

ED-D	DESIGNED: KFB/CAS	
ED-D	CHECKED: GVF	
ED-D	DRAWN: CAS/dae	
ED-GH	DESIGNED: FWC/DAC	
ED-GH	CHECKED: SVD/MSM	CAD FILE NAME: r4lo4.dgn
	DATE: MAY 92	SPEC NO:

DES
FLOOD CONTR
RO
STA
F
STAT





NOTES:

1. THE PROFILE GRADE HIGH FLOW CHANNEL IS AT BREAKLINE OF LOW FLOW AND HIGH FLOW CHANNELS.

REFERENCES:	PLATE NO.
1. CHANNEL SECTIONS	19-21
2. STORM SEWER SCHEDULE AND OUTLETS	41-42
3. LANDSCAPE AND LIGHTING PLAN	46

SYMBOL	DESCRIPTION	DATE	APPROVAL

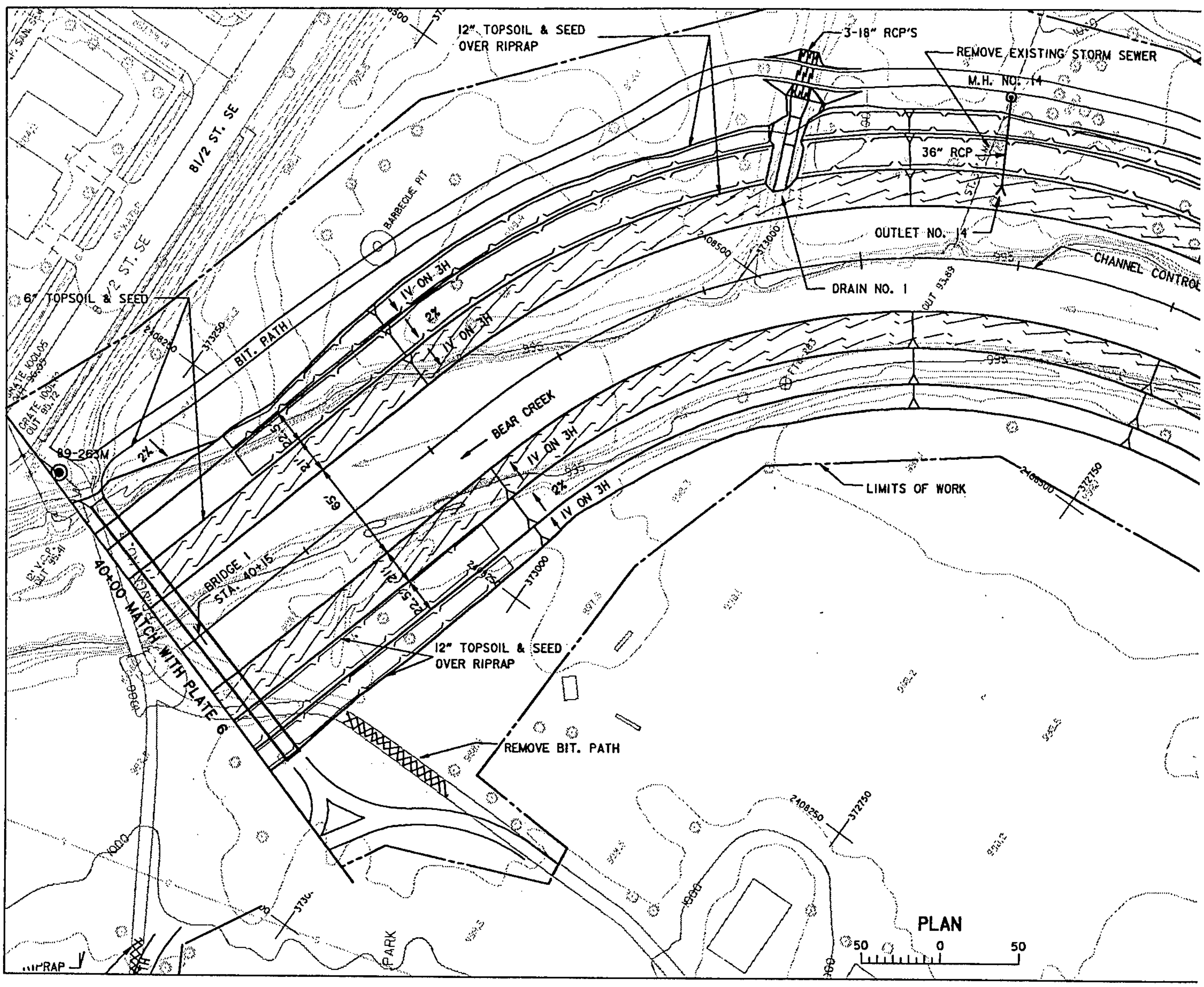
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

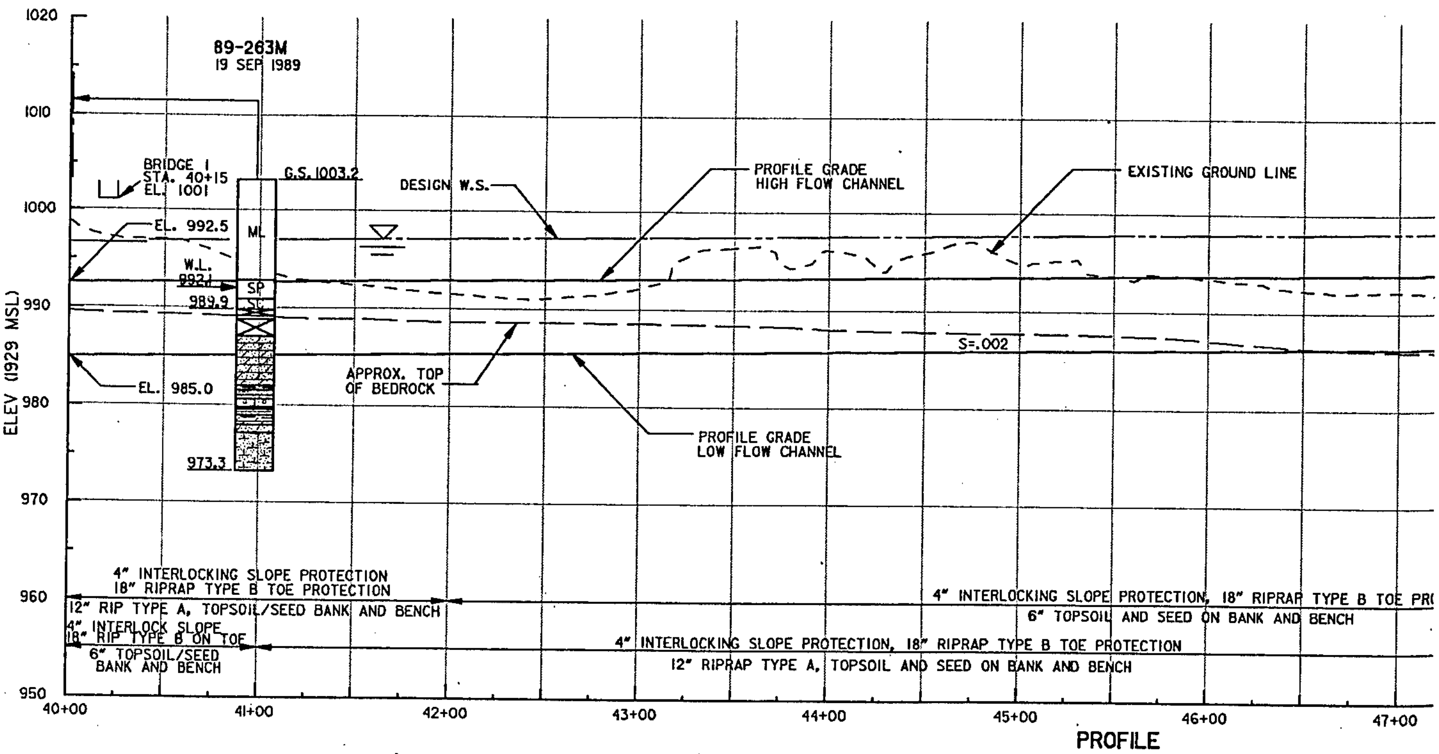
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 30+00 TO 40+00

ED-D DESIGNED: KFB/CAS	
ED-D CHECKED: GVF	
ED-D DRAWN: CAS/dae	
ED-CH DESIGNED: FWC/DAC	
ED-CH CHECKED: SVD/MSM	CAD FILE NAME: r4lo4.dgn
DATE: MAY 92	SPEC NO:

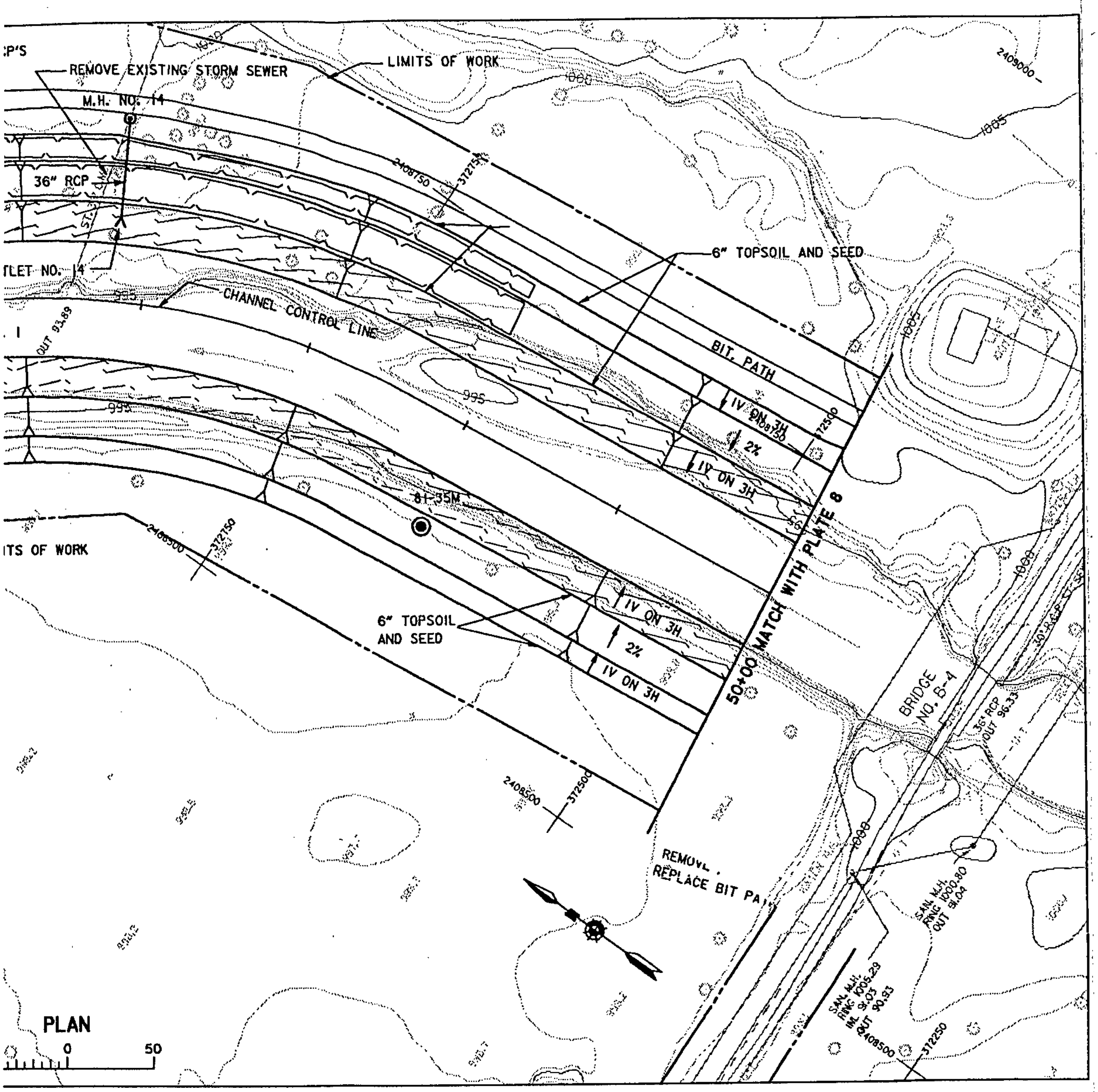
DRAWING NUMBER: PLATE 6 — SHT 6 OF 53



12" TOPSOIL & SEED OVER RIPRAP
3-18" RCP'S
REMOVE EXISTING STORM SEWER
M.H. NO. 14
36" RCP
81/2 ST. SE
BARBECUE PIT
OUTLET NO. 14
CHANNEL CONTROL
DRAIN NO. 1
6" TOPSOIL & SEED
BIT. PATH
1V ON 3H
2%
BEAR CREEK
89-263M
LIMITS OF WORK
65'
BRIDGE 1 STA. 40+15
40+00 MATCH WITH PLATE 6
REMOVE BIT. PATH
PARK
RIPRAP
PLAN
50
0
50

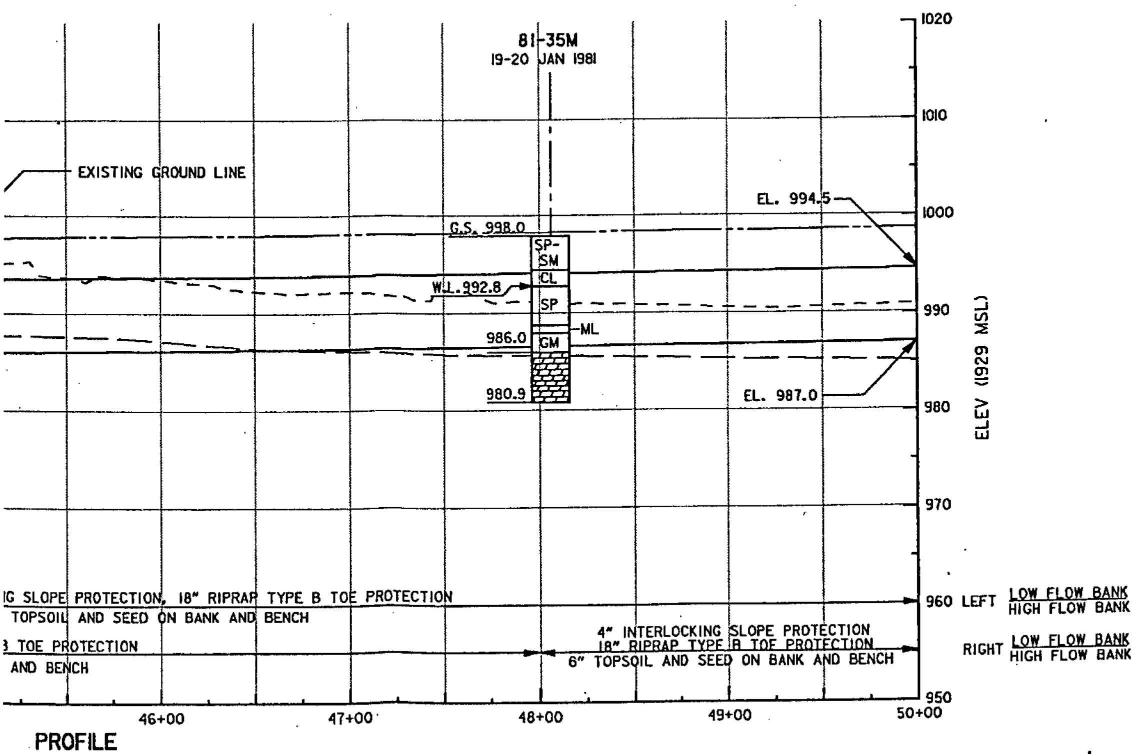


89-263M
19 SEP 1989
BRIDGE 1 STA. 40+15 EL. 1001
G.S. 1003.2
DESIGN W.S.
PROFILE GRADE HIGH FLOW CHANNEL
EXISTING GROUND LINE
EL. 992.5
ML
W.L. 992.1
SP
SC
989.9
S=.002
EL. 985.0
APPROX. TOP OF BEDROCK
PROFILE GRADE LOW FLOW CHANNEL
973.3
ELEV (1929 MSL)
1020
1010
1000
990
980
970
960
950
4" INTERLOCKING SLOPE PROTECTION
18" RIPRAP TYPE B TOE PROTECTION
12" RIP TYPE A, TOPSOIL/SEED BANK AND BENCH
4" INTERLOCK SLOPE
18" RIP TYPE B ON TOE
6" TOPSOIL/SEED BANK AND BENCH
4" INTERLOCKING SLOPE PROTECTION, 18" RIPRAP TYPE B TOE PRO
6" TOPSOIL AND SEED ON BANK AND BENCH
4" INTERLOCKING SLOPE PROTECTION, 18" RIPRAP TYPE B TOE PROTECTION
12" RIPRAP TYPE A, TOPSOIL AND SEED ON BANK AND BENCH
40+00
41+00
42+00
43+00
44+00
45+00
46+00
47+00
PROFILE



NOTES:

1. THE PROFILE GRADE HIGH FLOW CHAN
OF LOW FLOW AND HIGH FLOW CHANNEL

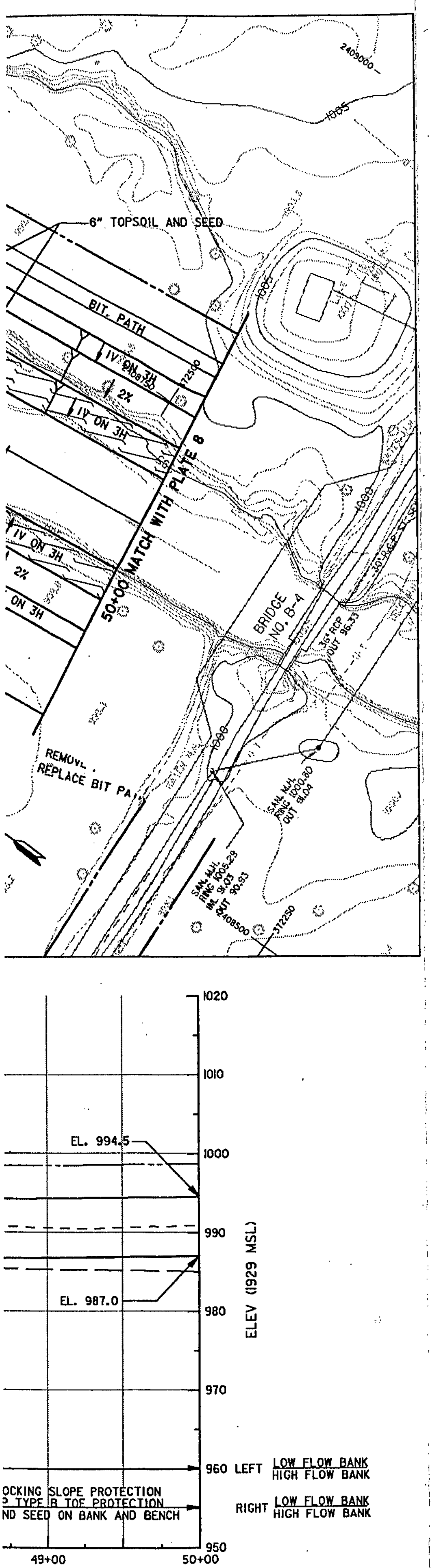


REFERENCES:

1. CHANNEL SECTIONS
2. BRIDGES 1,2, AND 3
3. STORMSEWER SCHEDULE AND OUTLET
3. LANDSCAPE AND LIGHTING PLAN

SYMBOL	DESC

AE APPROVING OFFICIAL:		FLOOD
ED-D	DESIGNED: KFB/CAS	
	CHECKED: GVF	
	DRAWN: CAS/dae	
ED-GH	DESIGNED: FWC/DAC	
	CHECKED: SVD/MSM	CAD FILE NAME: r41
DATE: MAY 92		SPEC NO:



NOTES:

1. THE PROFILE GRADE HIGH FLOW CHANNEL IS AT BREAKLINE OF LOW FLOW AND HIGH FLOW CHANNELS.

REFERENCES:	PLATE NO.
1. CHANNEL SECTIONS	20-21
2. BRIDGES 1,2, AND 3	34
3. STORMSEWER SCHEDULE AND OUTLETS	41-42
3. LANDSCAPE AND LIGHTING PLAN	47

SYMBOL	DESCRIPTION	DATE	APPROVAL

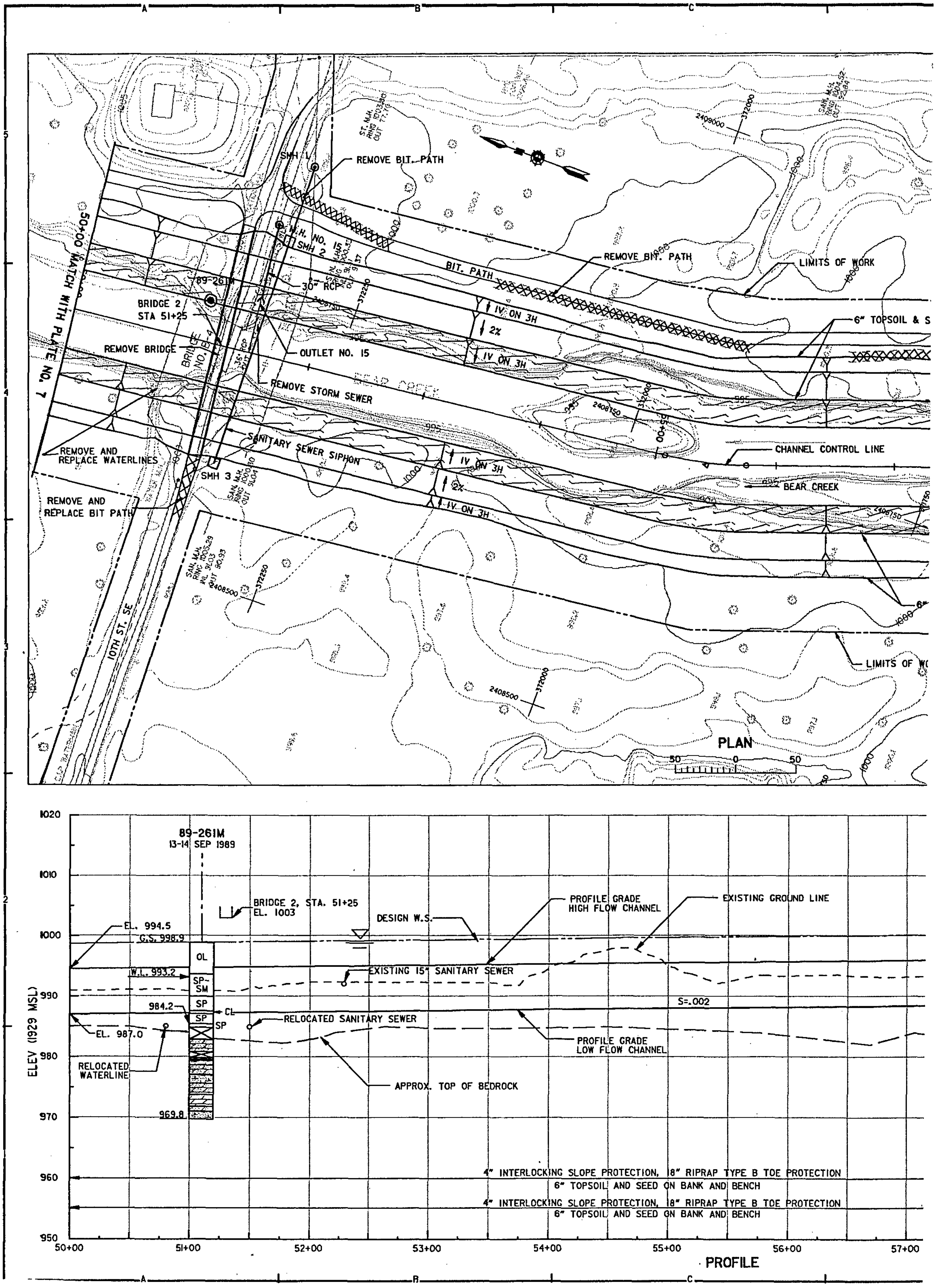
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

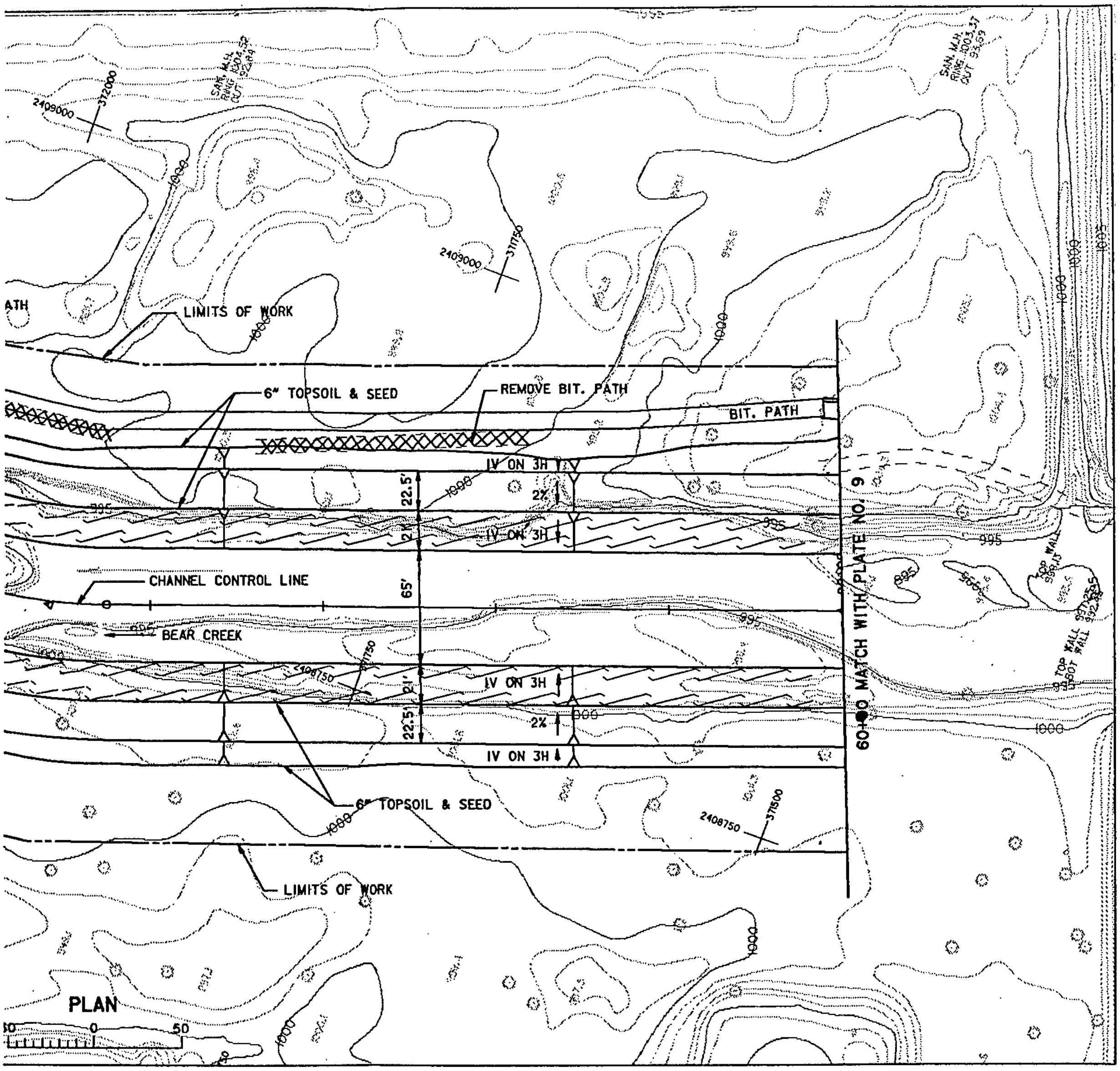
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 40+00 TO 50+00

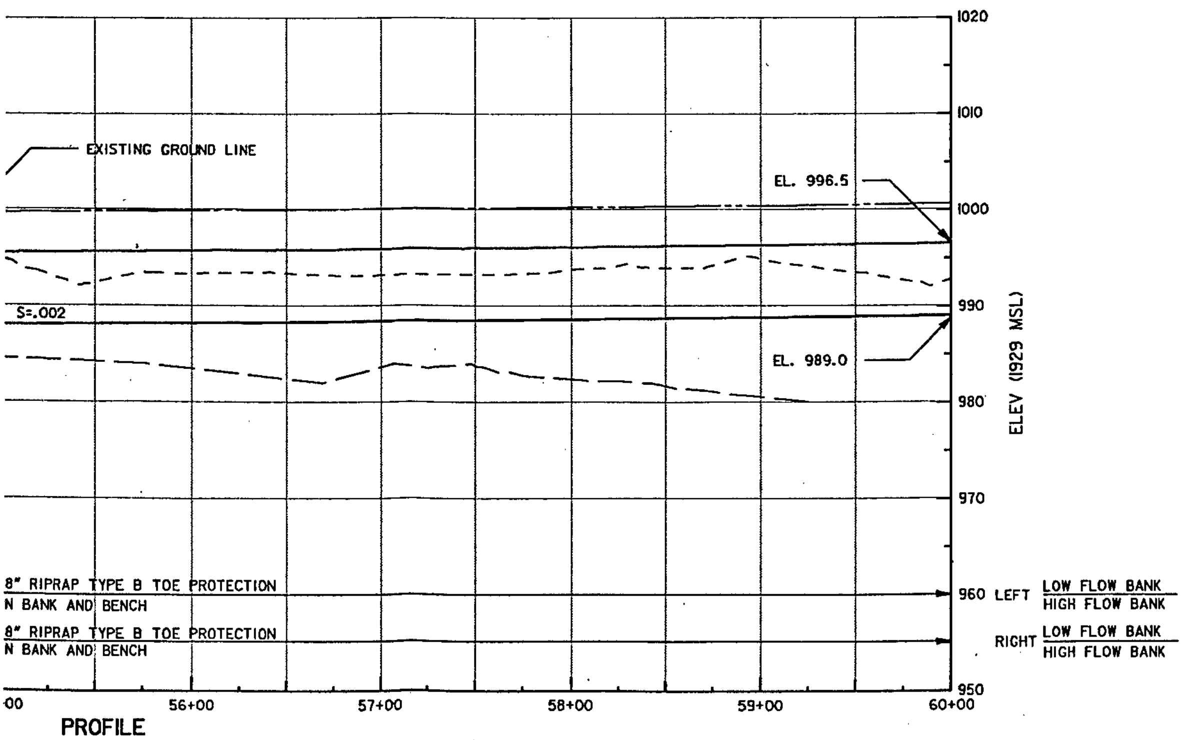
ED-D: DESIGNED: KFB/CAS; CHECKED: GVF; DRAWN: CAS/dae
ED-GH: DESIGNED: FWC/DAC; CHECKED: SVD/MSM

DATE: MAY 92 | CAD FILE NAME: r4lo5.dgn | SPEC NO: | DRAWING NUMBER: PLATE 7 | SHT 7 OF 53



REMOVE BIT. PATH
SMH 1
M.H. NO. 15
SMH 2
30" RCP
89-261M
BRIDGE 2
STA 51+25
50+00 MATCH WITH PLATE NO. 7
REMOVE BRIDGE
BRIDGE NO. 15-4
OUTLET NO. 15
REMOVE STORM SEWER
BEAR CREEK
REMOVE AND REPLACE WATERLINES
SANITARY SEWER SIPHON
SMH 3
REMOVE AND REPLACE BIT PATH
10TH ST. SE
BIT. PATH
1V ON 3H
2%
LIMITS OF WORK
6" TOPSOIL & S
CHANNEL CONTROL LINE
PLAN
89-261M
13-14 SEP 1989
BRIDGE 2, STA. 51+25
EL. 1003
DESIGN W.S.
PROFILE GRADE HIGH FLOW CHANNEL
EXISTING GROUND LINE
EL. 994.5
G.S. 998.9
W.L. 993.2
OL
SP-SM
SP
984.2
CL
EXISTING 15" SANITARY SEWER
S=.002
RELOCATED SANITARY SEWER
EL. 987.0
PROFILE GRADE LOW FLOW CHANNEL
RELOCATED WATERLINE
APPROX. TOP OF BEDROCK
969.8
ELEV (1929 MSL)
4" INTERLOCKING SLOPE PROTECTION, 18" RIPRAP TYPE B TOE PROTECTION
6" TOPSOIL AND SEED ON BANK AND BENCH
50+00
51+00
52+00
53+00
54+00
55+00
56+00
57+00
PROFILE





REFERENCES:

1. CHANNEL SECTIONS
2. BRIDGES 1, 2 AND 3
3. STORM SEWER SCHEDULE AND O
4. LANDSCAPE AND LIGHTING PLAN

SYMBOL

AE APPROVING OFFICIAL:

FLO

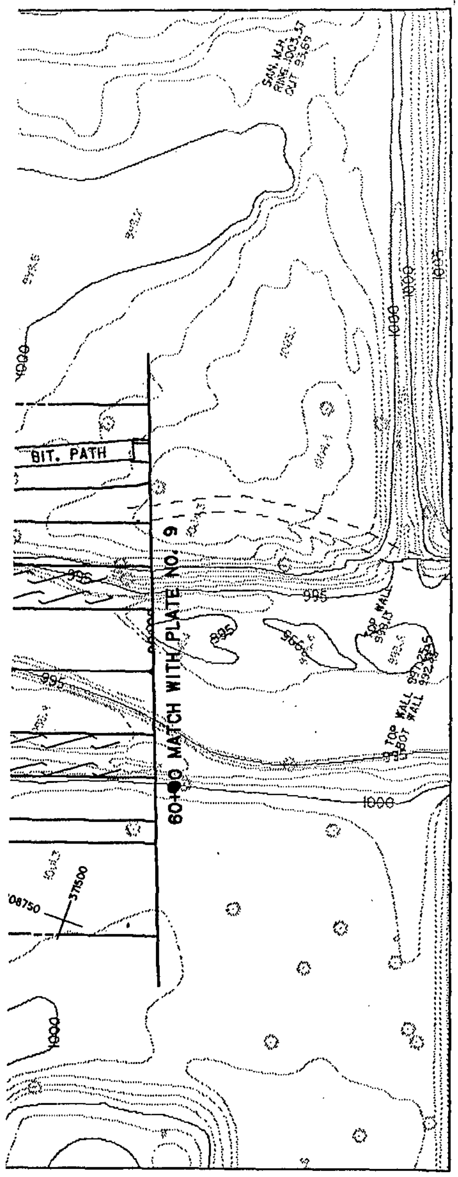
ED-D DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: KFB/dae

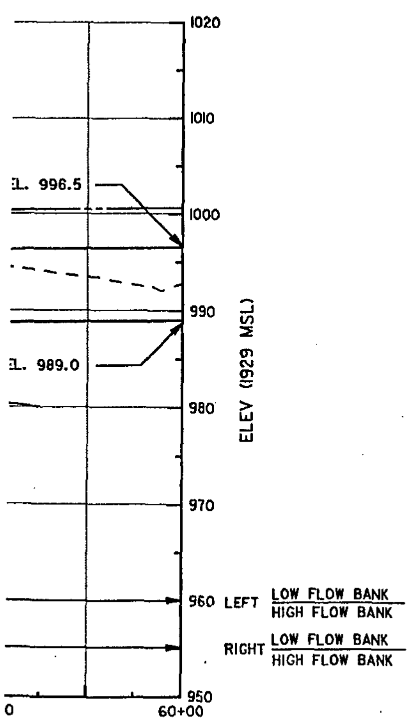
ED-GH DESIGNED: LMH/JLH
CHECKED: SAJ/NTS

CAD FILE NAME:

DATE: MAY 92

SPEC NO:





REFERENCES: **PLATE NO.**

1. CHANNEL SECTIONS	22
2. BRIDGES 1, 2 AND 3	34
3. STORM SEWER SCHEDULE AND OUTLETS	41-42
4. LANDSCAPE AND LIGHTING PLAN	48

SYMBOL	DESCRIPTION	DATE	APPROVAL

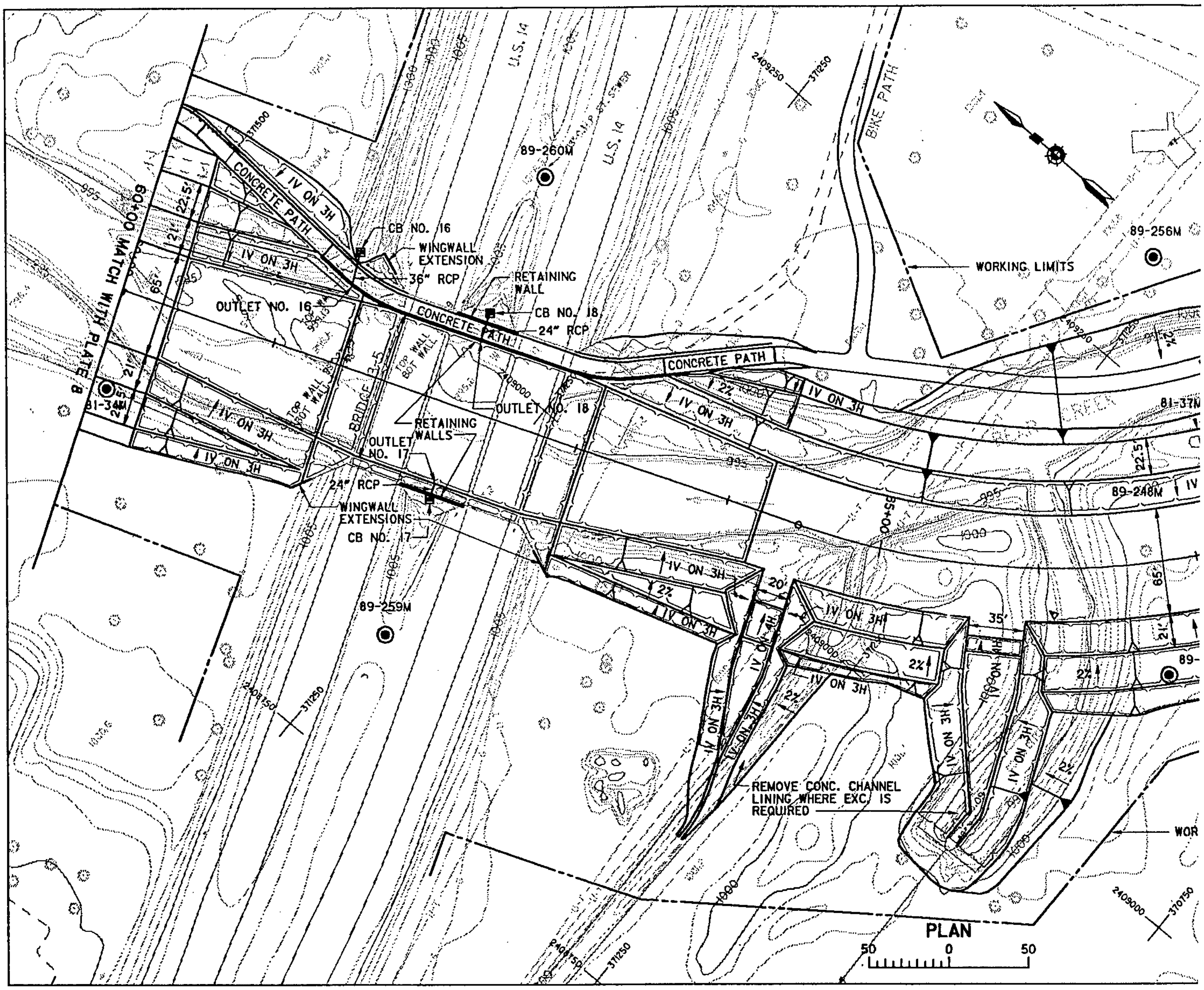
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

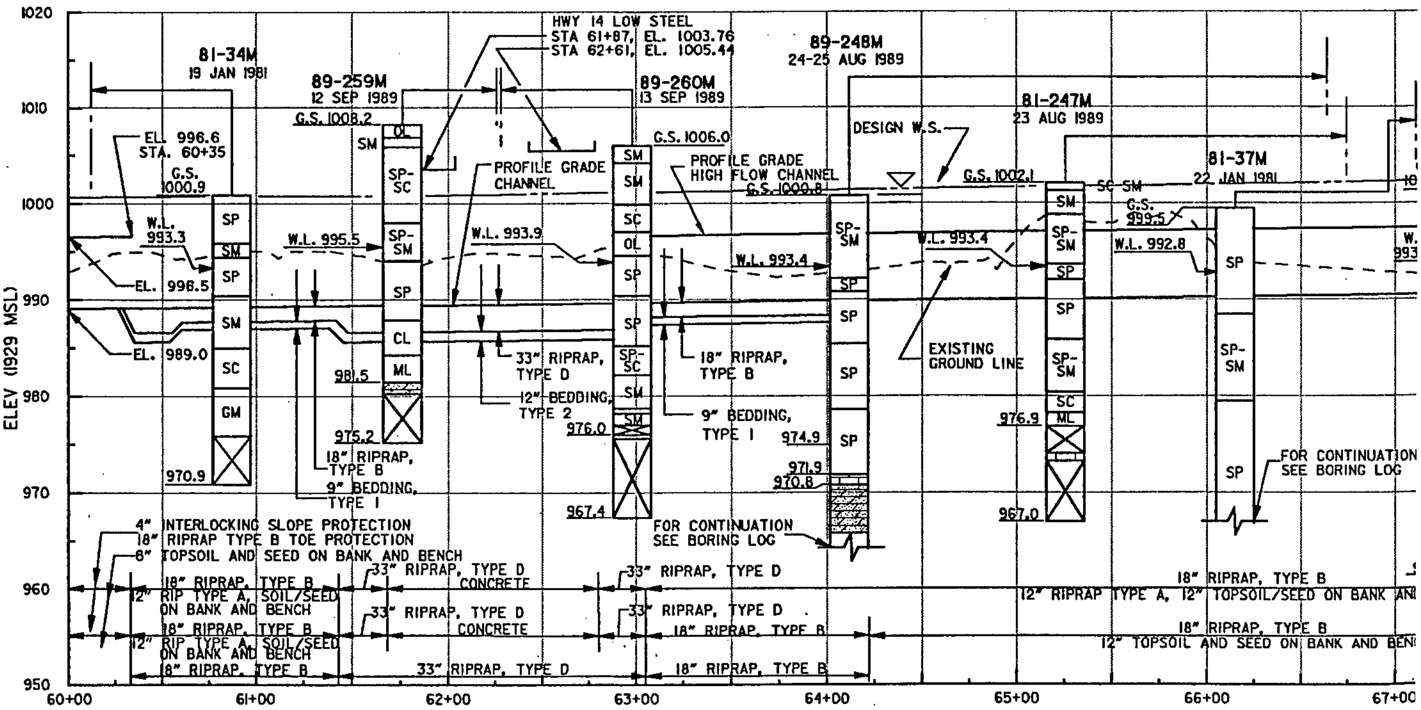
AE APPROVING OFFICIAL:

ED-D	DESIGNED: KFB/CAS	
ED-D	CHECKED: GVF	
ED-D	DRAWN: KFB/dae	
ED-GH	DESIGNED: LMH/JLH	
ED-GH	CHECKED: SAJ/NTS	
DATE: MAY 92		

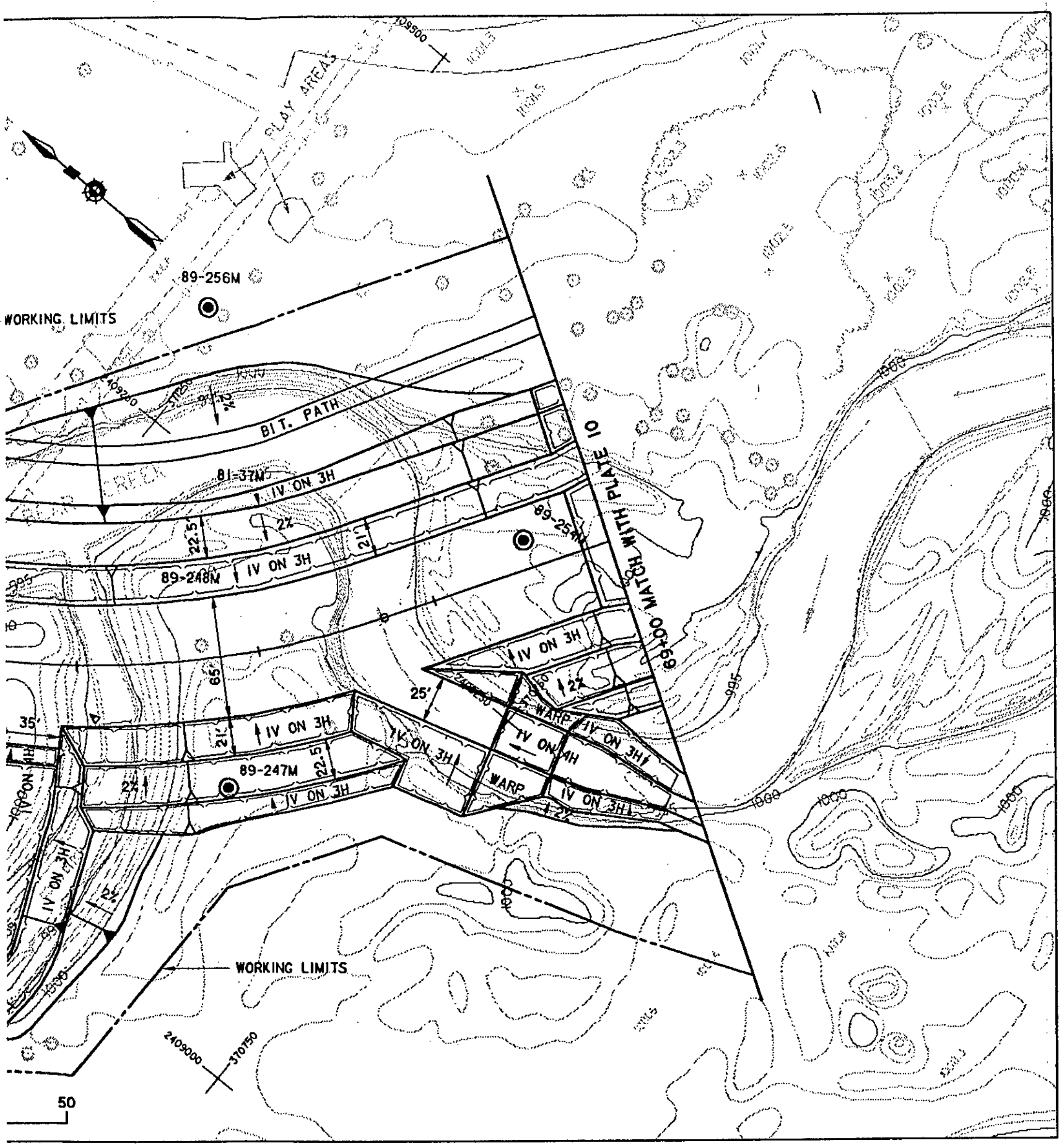
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 50+00 TO 60+00

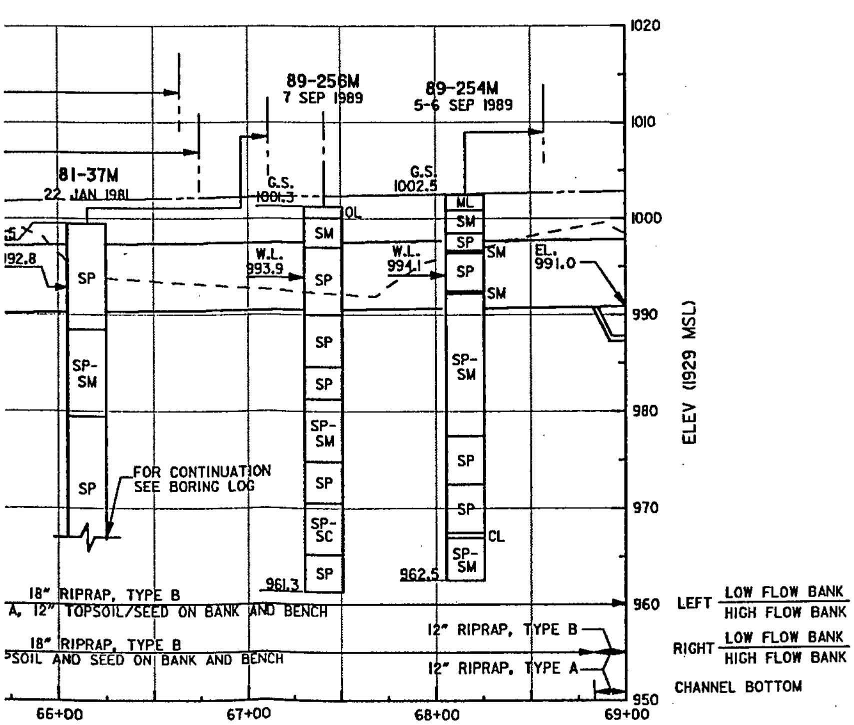
CAD FILE NAME: r4lo6.dgn	DRAWING NUMBER: PLATE 8	SHT 8 OF 53
SPEC NO:		


60+00 MATCH WITH PLATE 8
CONCRETE PATH
1V ON 3H
CB NO. 16
WINGWALL EXTENSION
36" RCP
RETAINING WALL
CB NO. 18
24" RCP
OUTLET NO. 16
OUTLET NO. 18
OUTLET NO. 17
BRIDGE 3-5
RETAINING WALLS
WINGWALL EXTENSIONS
CB NO. 17
U.S. 14
BIKE PATH
WORKING LIMITS
89-260M
89-259M
89-256M
89-248M
81-34M
81-37M
REMOVE CONC. CHANNEL LINING WHERE EXC. IS REQUIRED
2%
PLAN
50 0 50


ELEV (1929 MSL)
81-34M
19 JAN 1981
89-259M
12 SEP 1989
89-260M
13 SEP 1989
89-248M
24-25 AUG 1989
81-247M
23 AUG 1989
81-37M
22 JAN 1981
HWY 14 LOW STEEL
STA 61+87, EL. 1003.76
STA 62+61, EL. 1005.44
EL. 996.6
STA. 60+35
G.S. 1000.9
G.S. 1008.2
G.S. 1006.0
G.S. 1000.8
G.S. 1002.1
G.S. 999.5
DESIGN W.S.
PROFILE GRADE CHANNEL
PROFILE GRADE HIGH FLOW CHANNEL
W.L. 993.3
W.L. 995.5
W.L. 993.9
W.L. 993.4
W.L. 992.8
EL. 996.5
EL. 989.0
33" RIPRAP, TYPE D
12" BEDDING, TYPE 2
18" RIPRAP, TYPE B
9" BEDDING, TYPE 1
EXISTING GROUND LINE
FOR CONTINUATION SEE BORING LOG
4" INTERLOCKING SLOPE PROTECTION
18" RIPRAP TYPE B TOE PROTECTION
8" TOPSOIL AND SEED ON BANK AND BENCH
12" RIP TYPE A, SOIL/SEED ON BANK AND BENCH
33" RIPRAP, TYPE D CONCRETE
12" RIPRAP TYPE A, 12" TOPSOIL/SEED ON BANK AND
12" TOPSOIL AND SEED ON BANK AND BENCH
970.9
981.5
975.2
976.0
967.4
974.9
971.9
970.8
976.9
967.0
60+00
61+00
62+00
63+00
64+00
65+00
66+00
67+00

PROFILE





REFERENCES:

1. CHANNEL SECTIONS
2. BRIDGE U.S. 14
3. STORM SEWER SCHEDULE AND OUTLETS
4. LANDSCAPE AND LIGHTING PLAN

SYMBOL	DESCRIPTION

DI
ST. P

AE APPROVING OFFICIAL:

DESIGN MEM
FLOOD CONTROL - SOU
ROCHESTE
STAGE 4-
PLAN AN
STATION 60

ED-D	DESIGNED: KFB/CAS
	CHECKED: GVF
	DRAWN: KFB/dae
ED-GH	DESIGNED: FWC/DAC
	CHECKED: SVD/MSM

CAD FILE NAME: r4lo7.dgn

DATE: MAY 92

SPEC NO:

REFERENCES:

	PLATE NO.
1. CHANNEL SECTIONS	22-23
2. BRIDGE U.S. 14	32-33
3. STORM SEWER SCHEDULE AND OUTLETS	41-42
4. LANDSCAPE AND LIGHTING PLAN	49

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

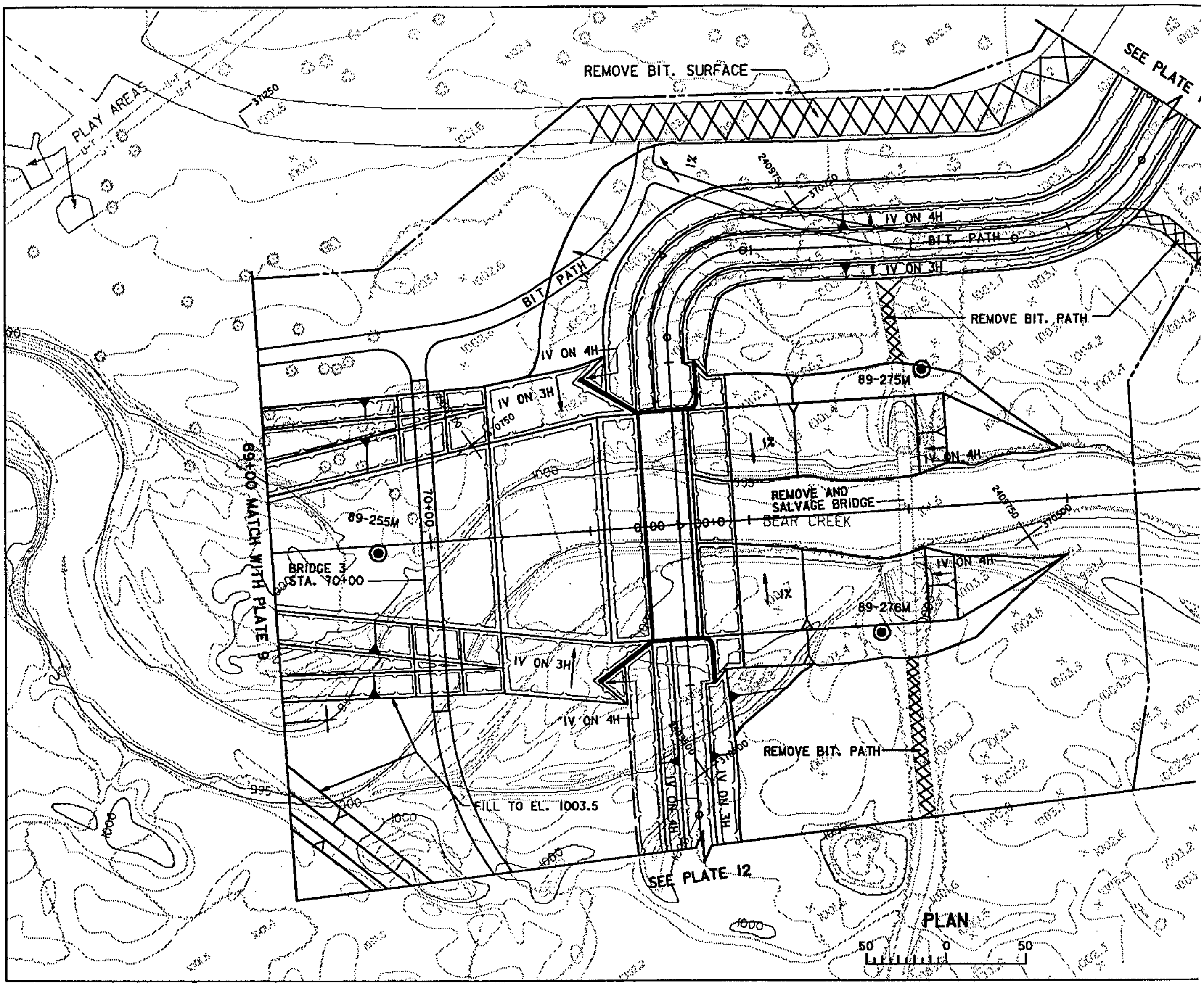
AE APPROVING OFFICIAL:

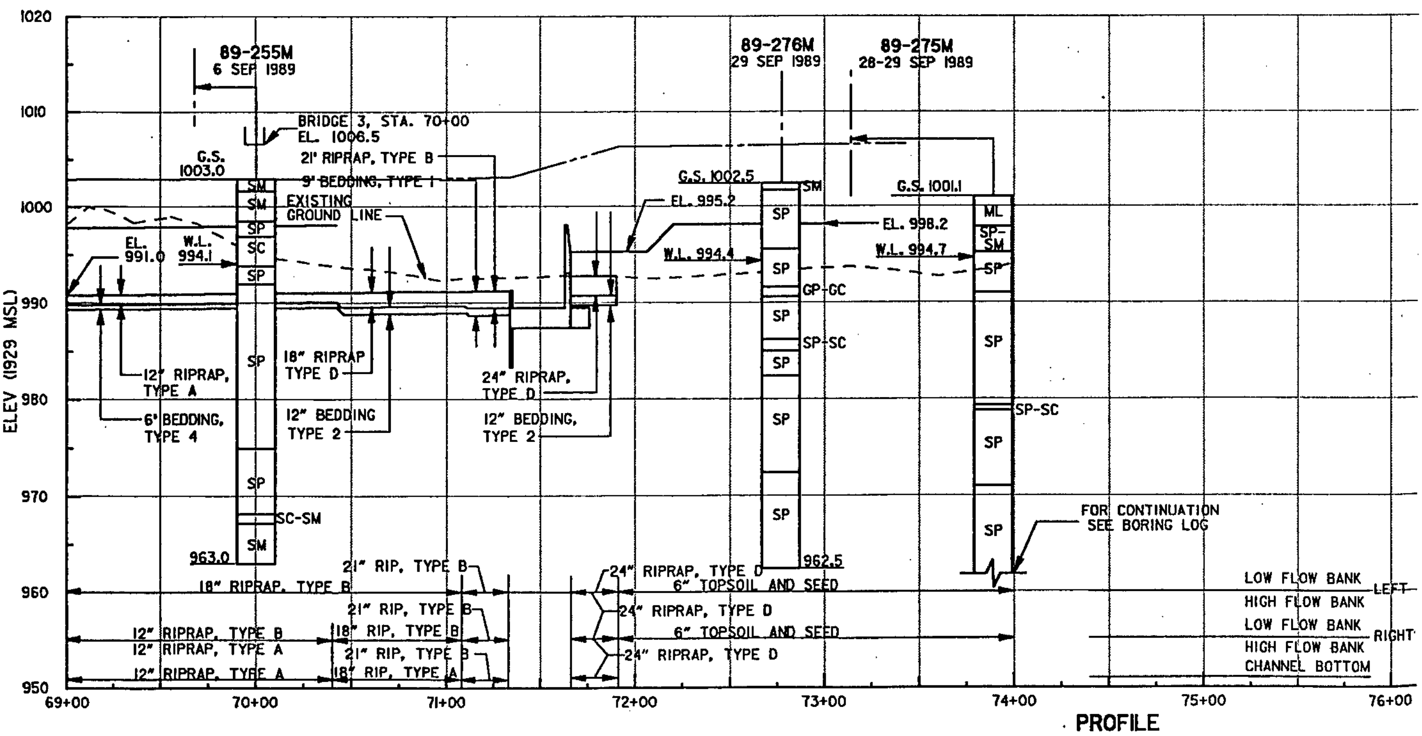
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 60+00 TO 69+00

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM
	DATE:	MAY 92

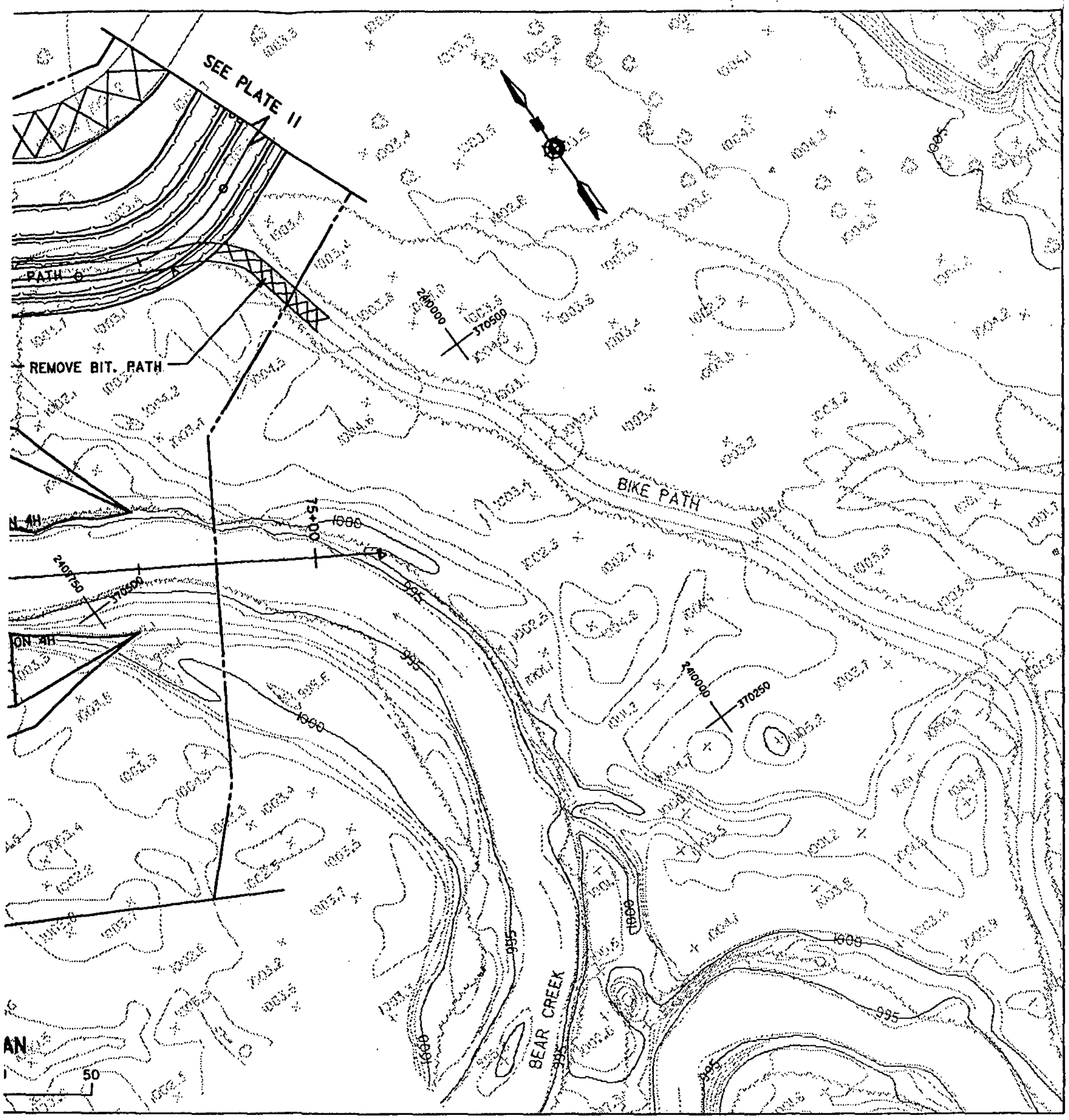
CAD FILE NAME: r4lo7.dgn
SPEC NO:
DRAWING NUMBER: PLATE 9
SHT 9 OF 53

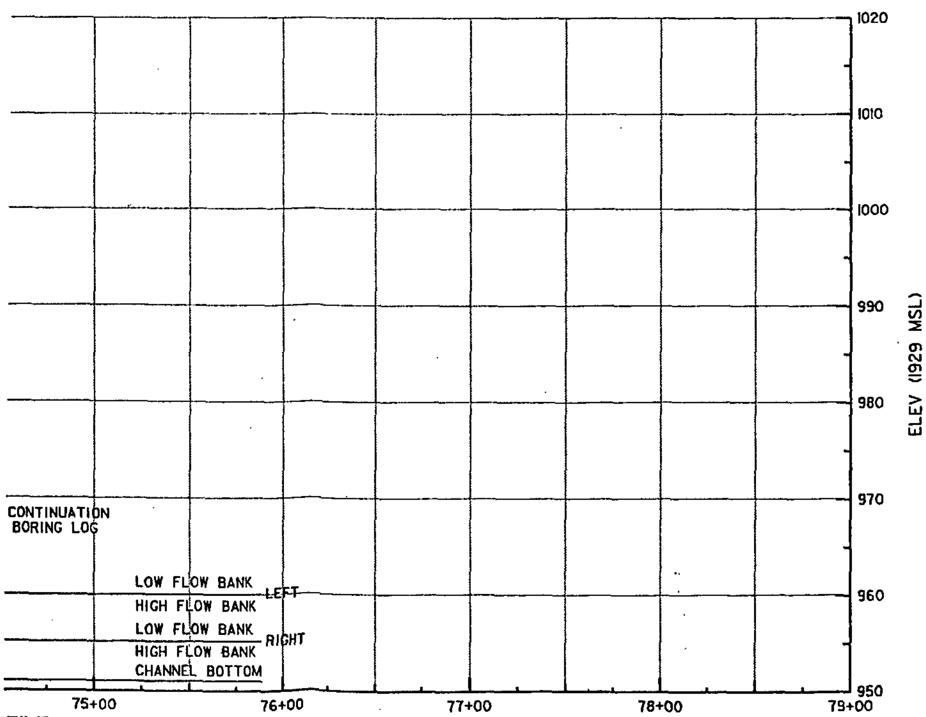
BANK
BANK
BANK
BANK


REMOVE BIT. SURFACE
SEE PLATE
PLAY AREAS
BIT. PATH
IV ON 4H
BIT. PATH
IV ON 3H
REMOVE BIT. PATH
IV ON 4H
IV ON 3H
89-275M
IV ON 4H
69+00 MATCH WITH PLATE 9
70+00
REMOVE AND SALVAGE BRIDGE
BEAR CREEK
89-255M
BRIDGE 3 STA. 70+00
IV ON 4H
89-276M
IV ON 3H
IV ON 4H
REMOVE BIT. PATH
IV ON 3H
IV ON 4H
995
FILL TO EL. 1003.5
1000
SEE PLATE 12
PLAN
50 0 50


1020
1010
1000
990
980
970
960
950
ELEV (1929 MSL)
89-255M
6 SEP 1989
89-276M
29 SEP 1989
89-275M
28-29 SEP 1989
BRIDGE 3, STA. 70+00
EL. 1006.5
21" RIPRAP, TYPE B
9" BEDDING, TYPE I
G.S. 1003.0
EXISTING GROUND LINE
EL. 991.0
W.L. 994.1
SM
SM
SP
SC
SP
SP
SP
SC-SM
SM
963.0
12" RIPRAP, TYPE A
6" BEDDING, TYPE 4
18" RIPRAP TYPE D
12" BEDDING TYPE 2
24" RIPRAP, TYPE D
12" BEDDING, TYPE 2
G.S. 1002.5
EL. 995.2
W.L. 994.4
SM
SP
SP
GP-GC
SP
SP-SC
SP
SP
SP
962.5
G.S. 1001.1
EL. 998.2
W.L. 994.7
ML
SP-SM
SP
SP
SP-SC
SP
SP
FOR CONTINUATION SEE BORING LOG
18" RIPRAP, TYPE B
21" RIP, TYPE B
24" RIPRAP, TYPE D
6" TOPSOIL AND SEED
21" RIP, TYPE B
18" RIP, TYPE B
24" RIPRAP, TYPE D
12" RIPRAP, TYPE B
12" RIPRAP, TYPE A
6" TOPSOIL AND SEED
21" RIP, TYPE B
18" RIP, TYPE A
12" RIPRAP, TYPE A
24" RIPRAP, TYPE D
LOW FLOW BANK
HIGH FLOW BANK
LEFT
LOW FLOW BANK
HIGH FLOW BANK
RIGHT
CHANNEL BOTTOM
69+00
70+00
71+00
72+00
73+00
74+00
75+00
76+00

PROFILE





FILE

REFERENCES:

1. CHANNEL SECTIONS
2. PEDESTRIAN BRIDGE
3. UPSTREAM DROP STRUCTURE
4. LANDSCAPE AND LIGHTING PLAN

SYMBOL	DESCRIPTION

AE APPROVING OFFICIAL:

ED-D: DESIGNED: KFB/CAS — CHECKED: GVF — DRAWN: KFB/dae

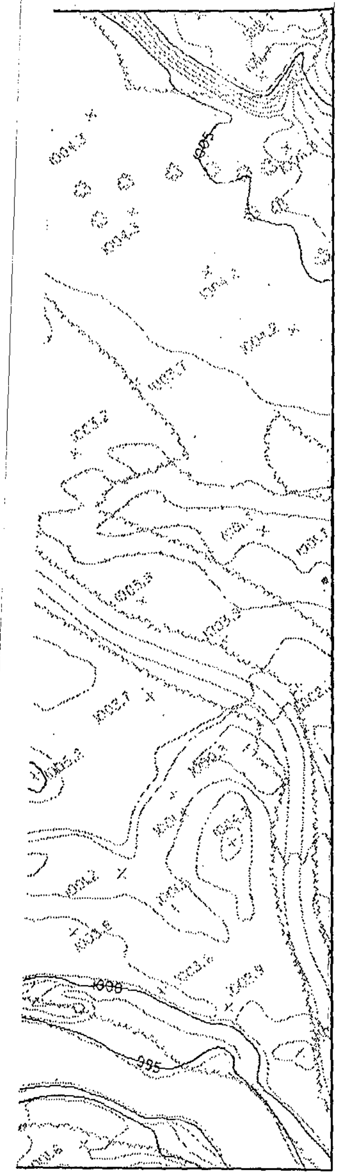
ED-GH: DESIGNED: FWC/DAC — CHECKED: SVD/MSM

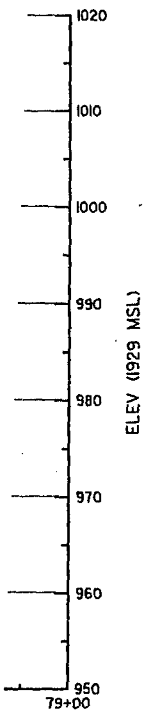
DATE: MAY 92

DESIGN
FLOOD CONTROL
ROCHE
STAGE
PLA
STATION

CAD FILE NAME: r4lo8.dgn

SPEC NO:





REFERENCES:

	PLATE NO.
1. CHANNEL SECTIONS	23-24
2. PEDESTRIAN BRIDGE	34
3. UPSTREAM DROP STRUCTURE	38-39
4. LANDSCAPE AND LIGHTING PLAN	50

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

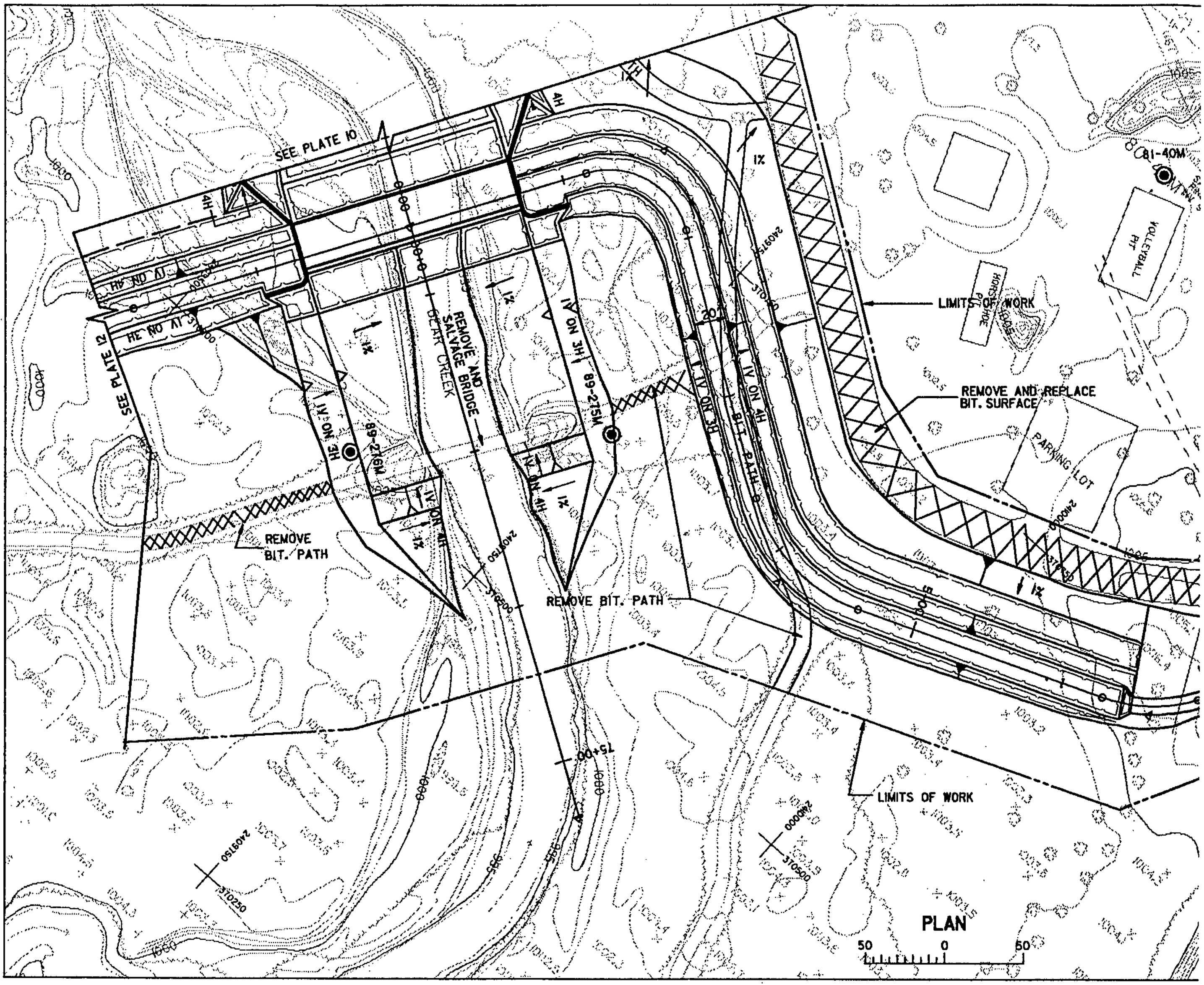
ED-D
DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: KFB/dae

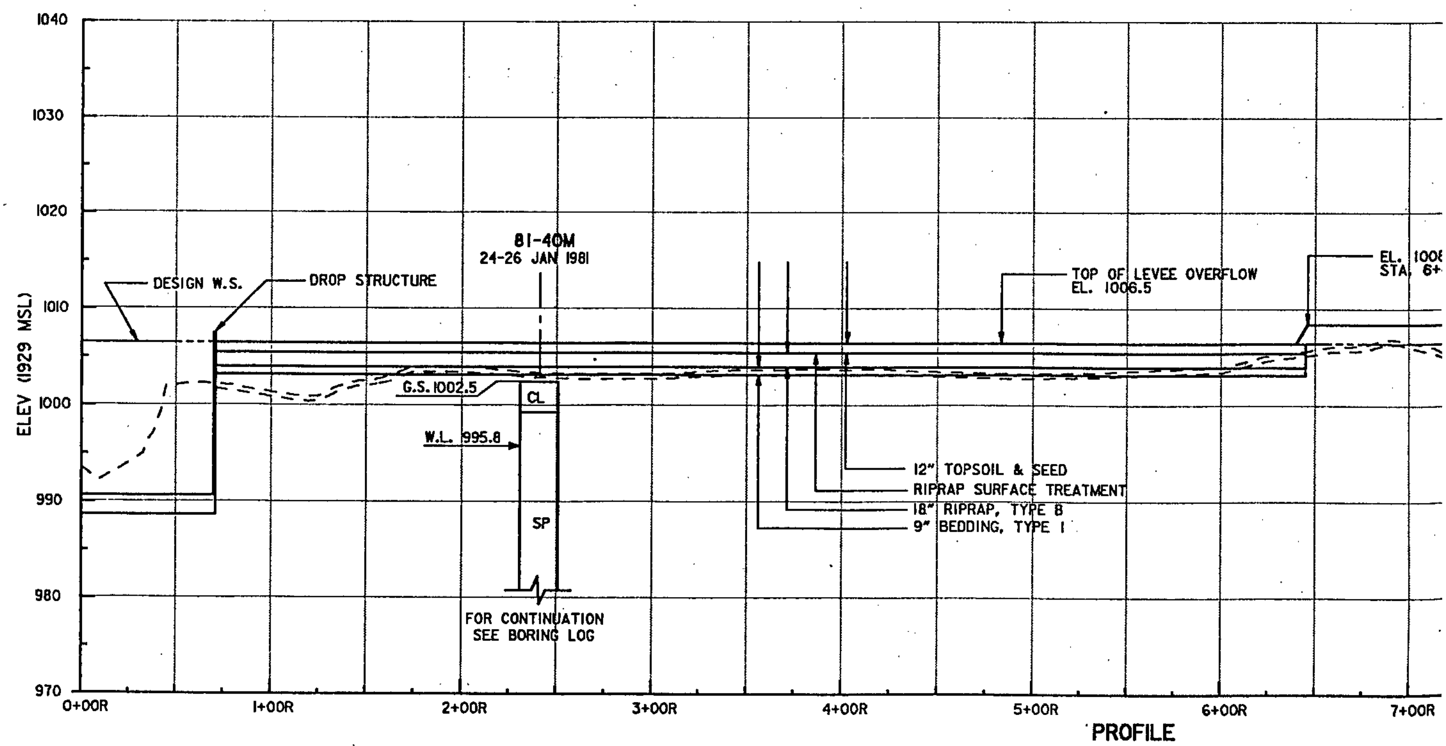
ED-GH
DESIGNED: FWC/DAC
CHECKED: SVD/MSM

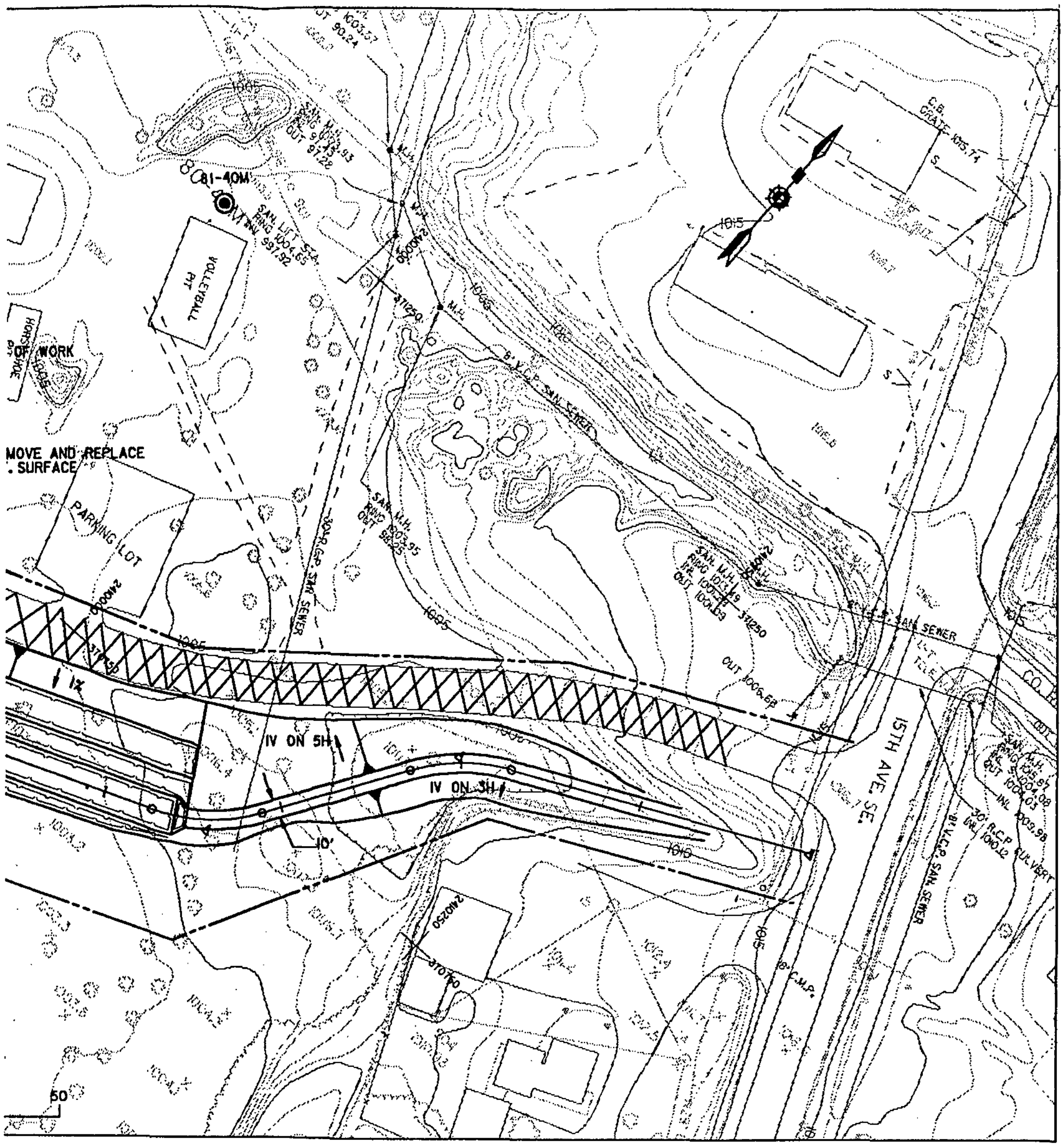
DATE: MAY 92

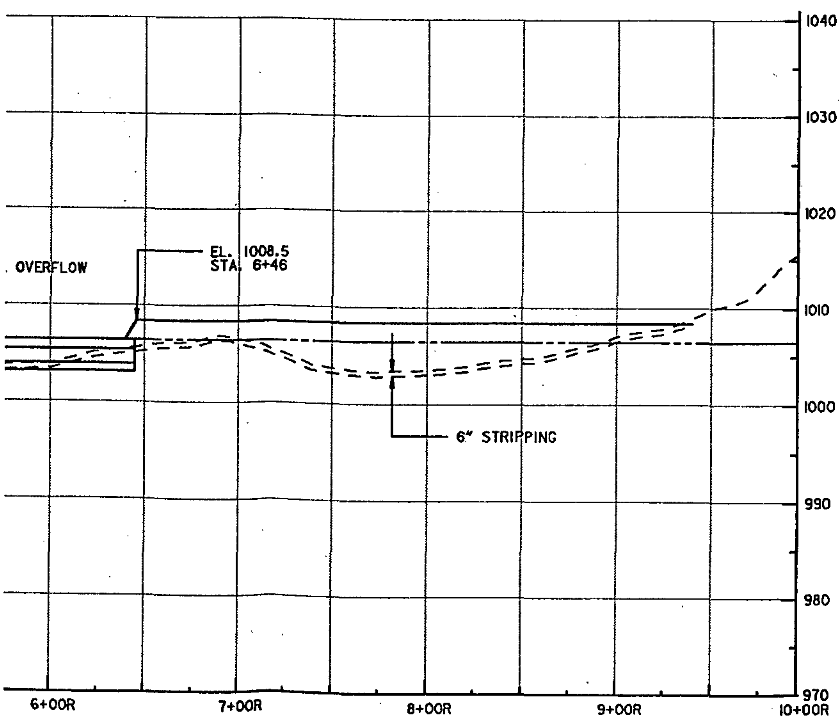
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
PLAN AND PROFILE
STATION 69+00 TO 75+35

CAD FILE NAME: r4lo8.dgn
SPEC NO:
DRAWING NUMBER: PLATE 10
SHT 10 OF 53


SEE PLATE 10
SEE PLATE 12
REMOVE AND SALVAGE BRIDGE
BEAR CREEK
89-276M
89-275M
81-40M
REMOVE BIT. PATH
REMOVE BIT. PATH
LIMITS OF WORK
LIMITS OF WORK
REMOVE AND REPLACE BIT. SURFACE
PARKING LOT
VOLLEYBALL PIT
HORSE SHOE PITS
BIT. PATH
1V ON 3H
1V ON 4H
1%
4H
75+00
PLAN
50 0 50


ELEV (1929 MSL)
1040
1030
1020
1010
1000
990
980
970
81-40M
24-26 JAN 1981
DESIGN W.S.
DROP STRUCTURE
TOP OF LEVEE OVERFLOW
EL. 1006.5
EL. 1008
STA. 6+
G.S. 1002.5
CL
W.L. 995.8
SP
FOR CONTINUATION
SEE BORING LOG
12" TOPSOIL & SEED
RIPRAP SURFACE TREATMENT
18" RIPRAP, TYPE B
9" BEDDING, TYPE I
0+00R
1+00R
2+00R
3+00R
4+00R
5+00R
6+00R
7+00R
PROFILE





REFERENCES:

1. RIGHT LEVEE SECTIONS
2. LANDSCAPE AND LIGHTING PLAN

SYMBOL	DESCRIPTION

DE
ST. PA

AE APPROVING OFFICIAL:

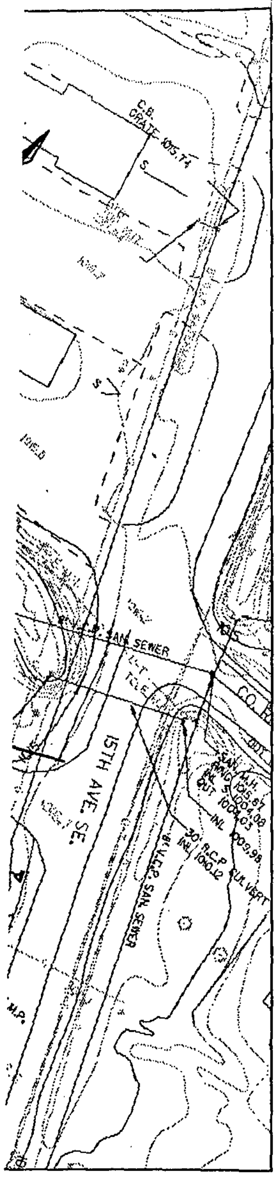
DESIGN MEM
FLOOD CONTROL - SOU
ROCHESTER
STAGE 4-
LEVEE PLAN
STATION 0+

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM
DATE: MAY 92		

CAD FILE NAME: r4lo9.dgn

DR

SPEC NO:



140
030
020
010
000
990
980
970
00R

ELEV (1929 MSL)

REFERENCES: **PLATE NO.**

1. RIGHT LEVEE SECTIONS 25
2. LANDSCAPE AND LIGHTING PLAN 52

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LEVEE PLAN AND PROFILE
STATION 0+00R TO 9+35R

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM

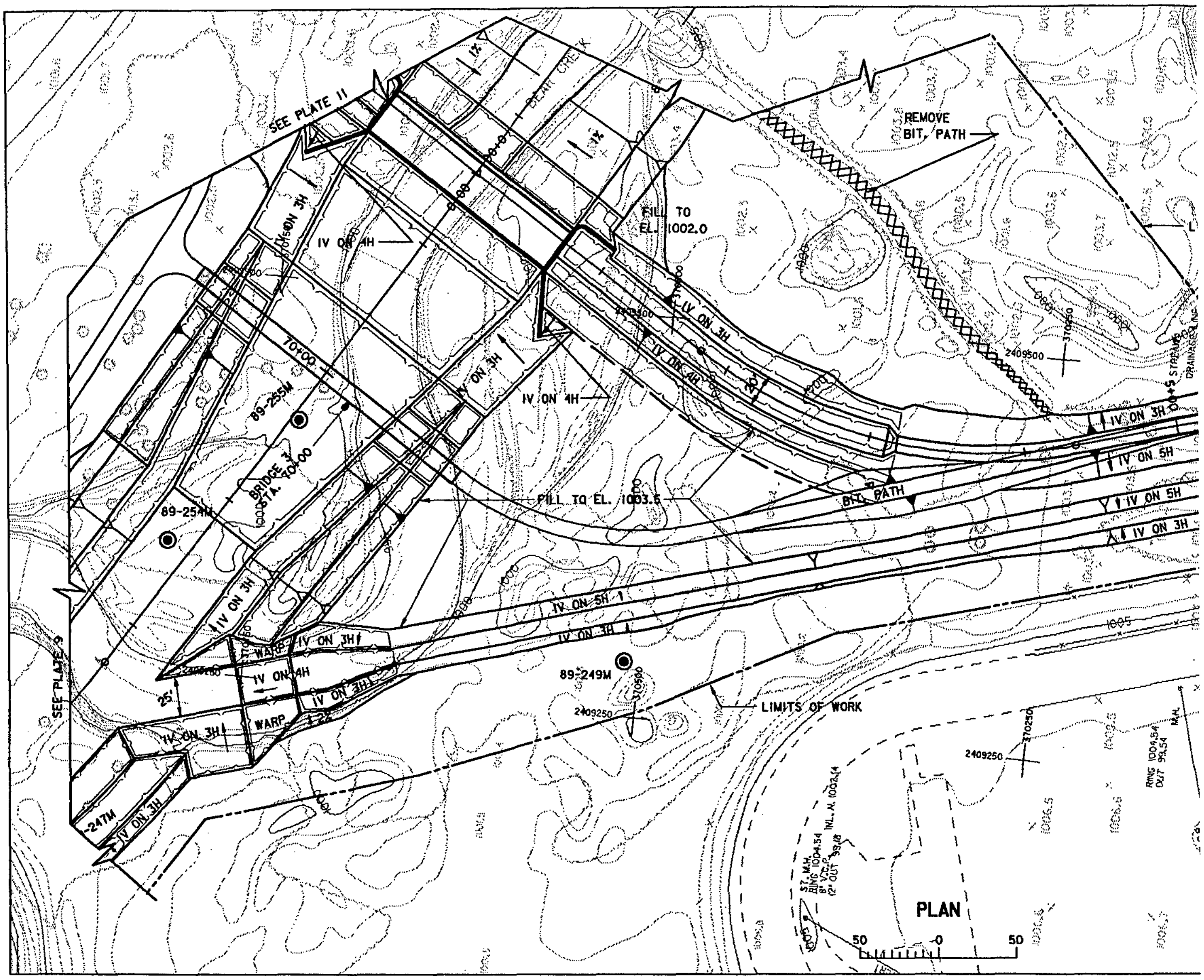
DATE: MAY 92

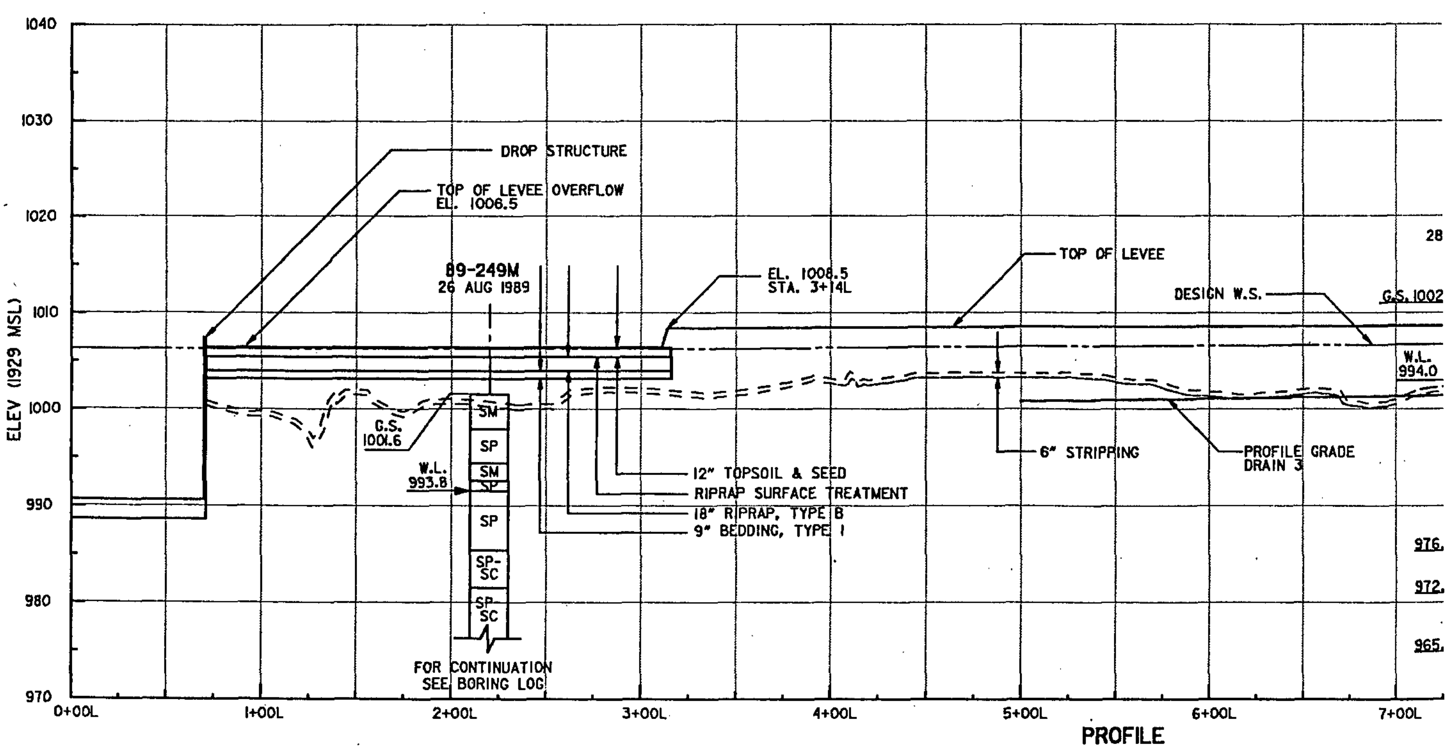
CAD FILE NAME: r4lo9.dgn

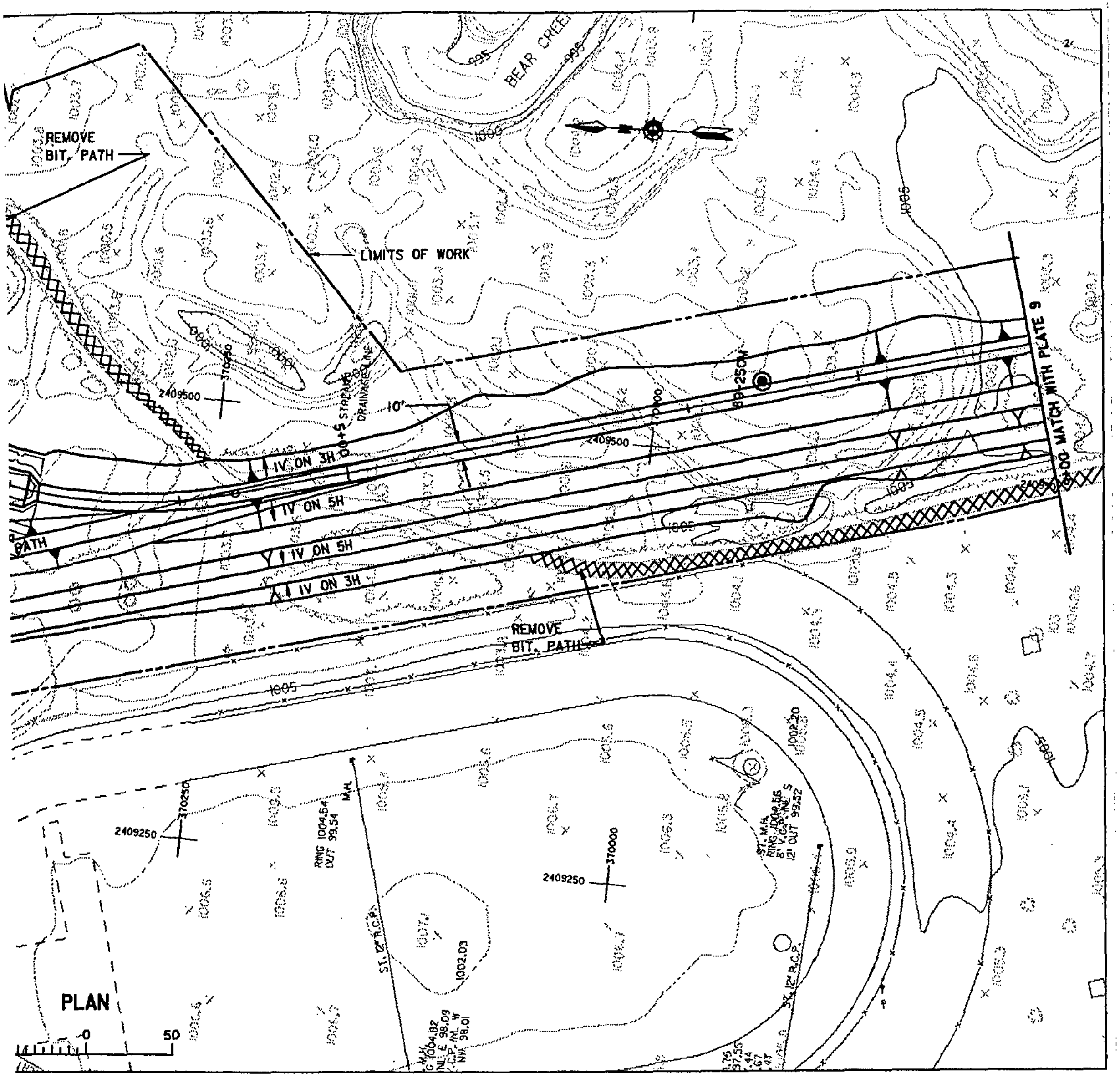
SPEC NO:

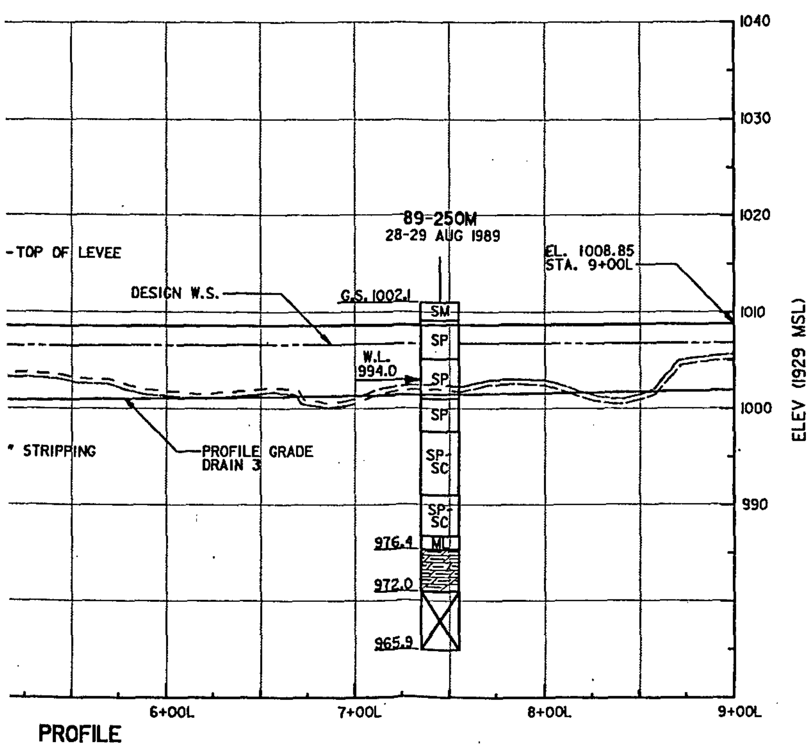
DRAWING NUMBER: PLATE II

SHT II OF 53


SEE PLATE 11
REMOVE BIT. PATH
FILL TO EL. 1002.0
IV ON 3H
IV ON 4H
70+00
89-255M
BRIDGE 3 STA. 70+00
89-254M
FILL TO EL. 1003.5
BIT. PATH
IV ON 5H
IV ON 3H
WARP
25'
89-249M
2409250
370500
LIMITS OF WORK
SEE PLATE 9
-247M
2409500
370250
PLAN
50
0
50


1040
1030
1020
1010
1000
990
980
970
ELEV (1929 MSL)
DROP STRUCTURE
TOP OF LEVEE OVERFLOW EL. 1006.5
89-249M
26 AUG 1989
EL. 1008.5
STA. 3+14L
TOP OF LEVEE
DESIGN W.S.
G.S. 1002
W.L. 994.0
G.S. 1001.6
W.L. 993.8
SM
SP
SP-SC
FOR CONTINUATION SEE BORING LOG
12" TOPSOIL & SEED
RIPRAP SURFACE TREATMENT
18" RIPRAP, TYPE B
9" BEDDING, TYPE I
6" STRIPPING
PROFILE GRADE DRAIN 3
28
976.
972.
965.
0+00L
1+00L
2+00L
3+00L
4+00L
5+00L
6+00L
7+00L
PROFILE



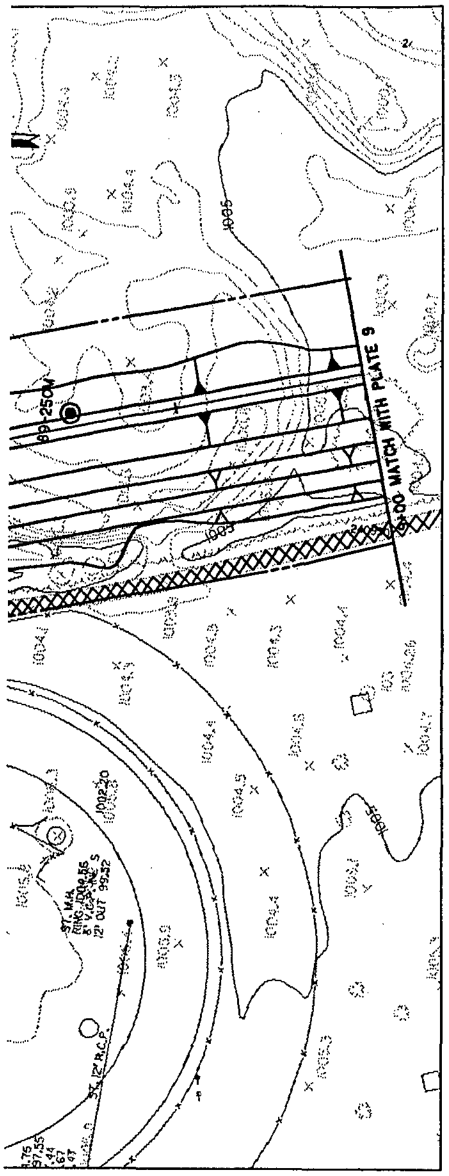


REFERENCES:

1. LEFT LEVEE SECTIONS
2. LANDSCAPE AND LIGHTING PLAN

SYMBOL	DES
AE APPROVING OFFICIAL:	FLOOD

ED-D	DESIGNED: KFB/CAS	
	CHECKED: GVF	
	DRAWN: KFB/dae	
ED-GH	DESIGNED: FWC/DAC	
	CHECKED: SVD/MSM	CAD FILE NAME: r4
DATE: MAY 92		SPEC NO:



ELEV (1929 MSL)

REFERENCES: | **PLATE NO.**

1. LEFT LEVEE SECTIONS — 27
2. LANDSCAPE AND LIGHTING PLAN — 52

SYMBOL	DESCRIPTION	DATE	APPROVAL

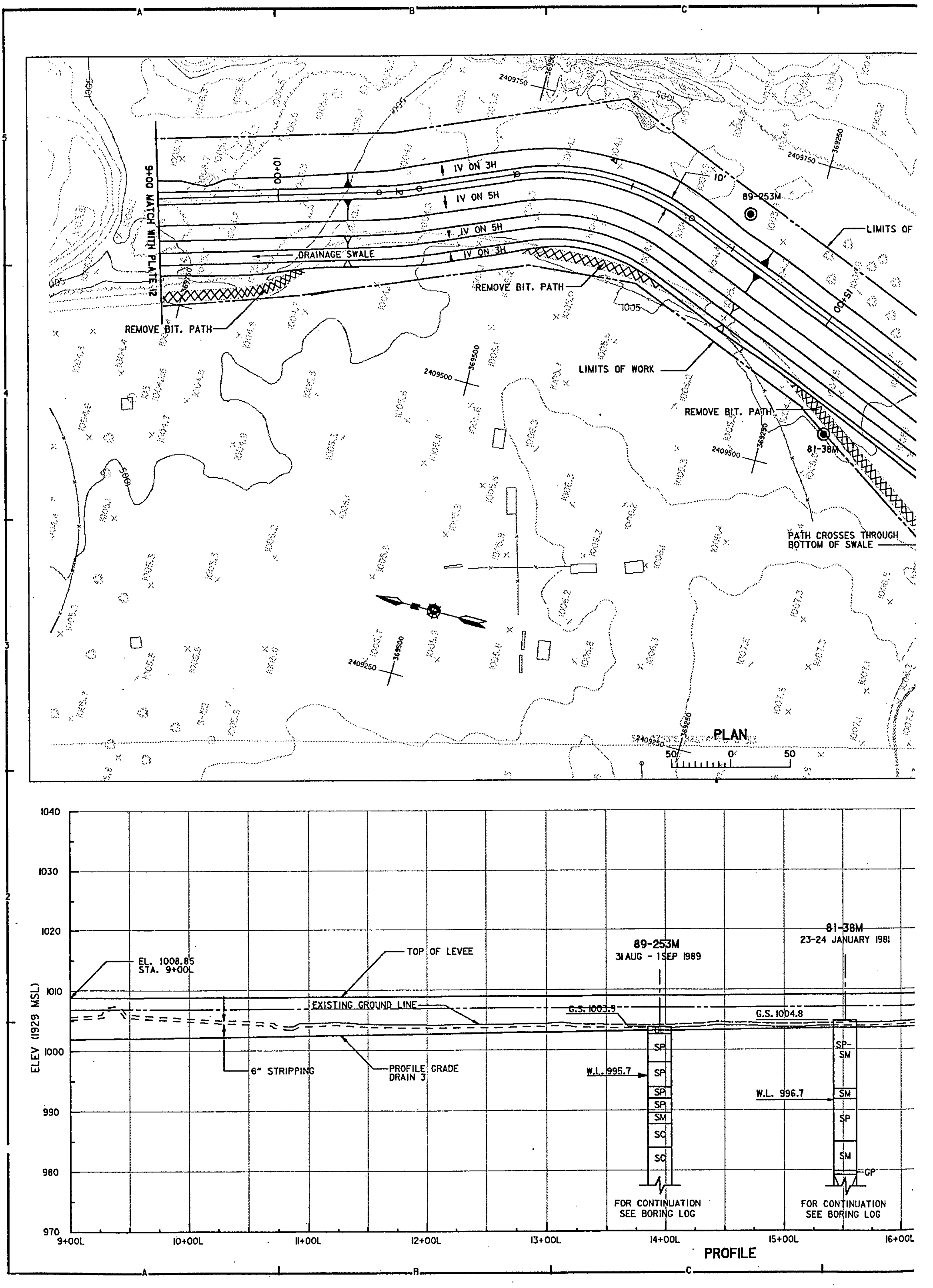
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

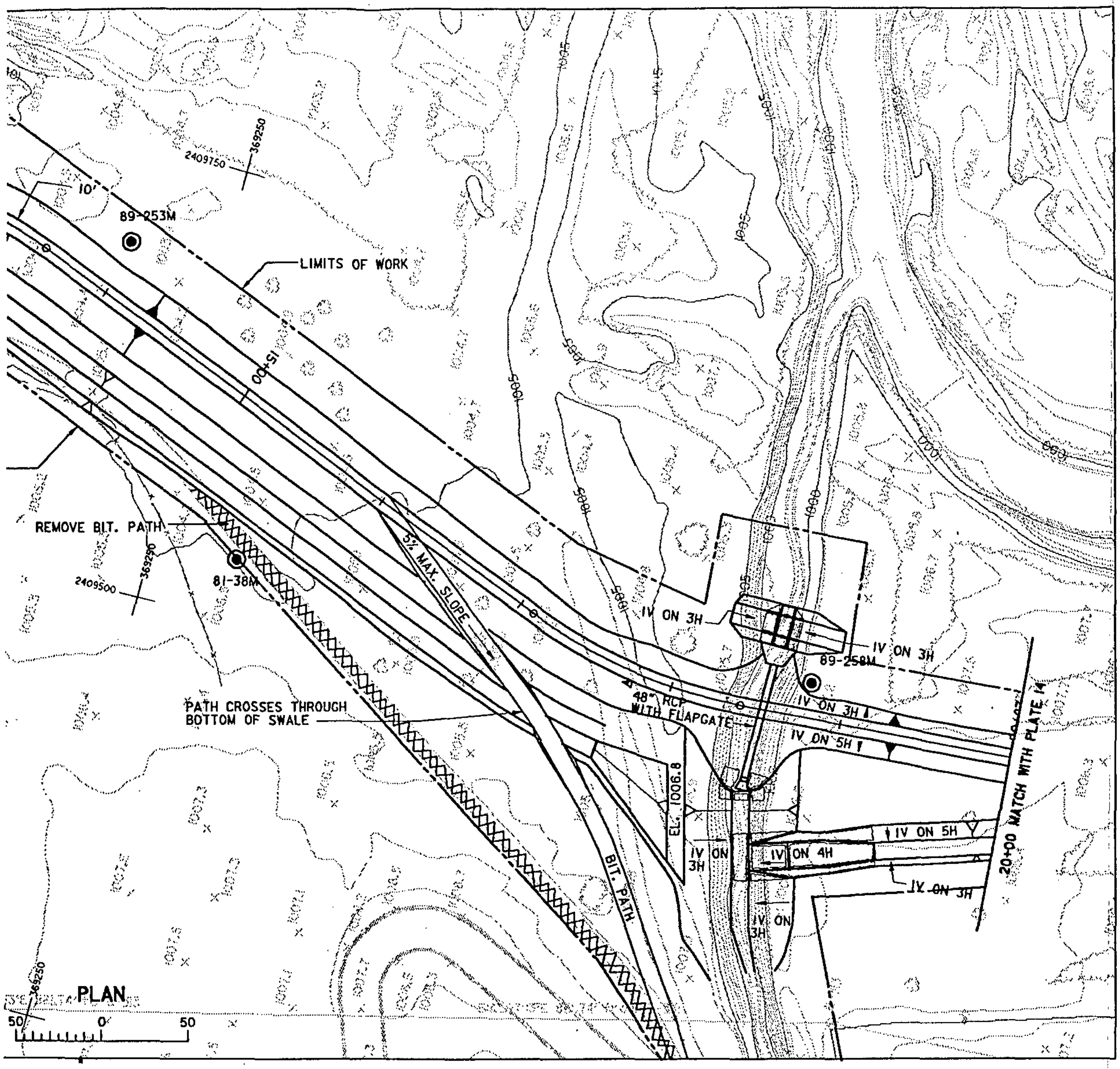
ED-D DESIGNED:	KFB/CAS
ED-D CHECKED:	GVF
ED-D DRAWN:	KFB/dae
ED-GH DESIGNED:	FWC/DAC
ED-GH CHECKED:	SVD/MSM
DATE:	MAY 92

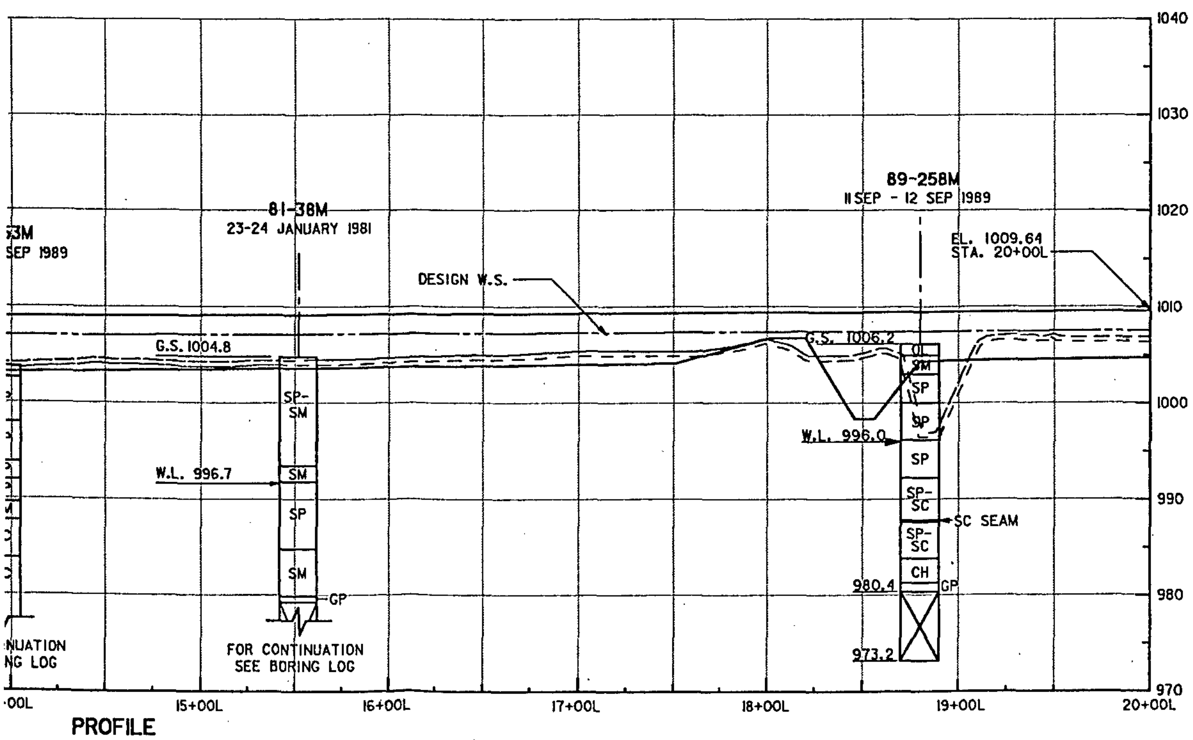
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LEVEE PLAN AND PROFILE
STATION 0+00L TO 9+00L

CAD FILE NAME: r4lol0.dgn	DRAWING NUMBER:	SHT 12	
SPEC NO:	PLATE 12	OF 53	



9+00 MATCH WITH PLATE 12
10+00
15+00
1V ON 3H
1V ON 5H
1V ON 5H
1V ON 3H
DRAINAGE SWALE
REMOVE BIT. PATH
REMOVE BIT. PATH
REMOVE BIT. PATH
LIMITS OF WORK
LIMITS OF
10'
89-253M
81-38M
PATH CROSSES THROUGH
BOTTOM OF SWALE
2409750
2409500
2409250
369500
369250
1005
PLAN
50
0
50
1040
1030
1020
1010
1000
990
980
970
ELEV (1929 MSL)
EL. 1008.85
STA. 9+00L
TOP OF LEVEE
EXISTING GROUND LINE
6" STRIPPING
PROFILE GRADE
DRAIN 3
89-253M
31 AUG - 1 SEP 1989
81-38M
23-24 JANUARY 1981
G.S. 1003.9
G.S. 1004.8
W.L. 995.7
W.L. 996.7
SP
SP
SP
SP
SM
SC
SC
SP-SM
SM
SP
SM
GP
FOR CONTINUATION
SEE BORING LOG
FOR CONTINUATION
SEE BORING LOG
9+00L
10+00L
11+00L
12+00L
13+00L
14+00L
15+00L
16+00L
PROFILE

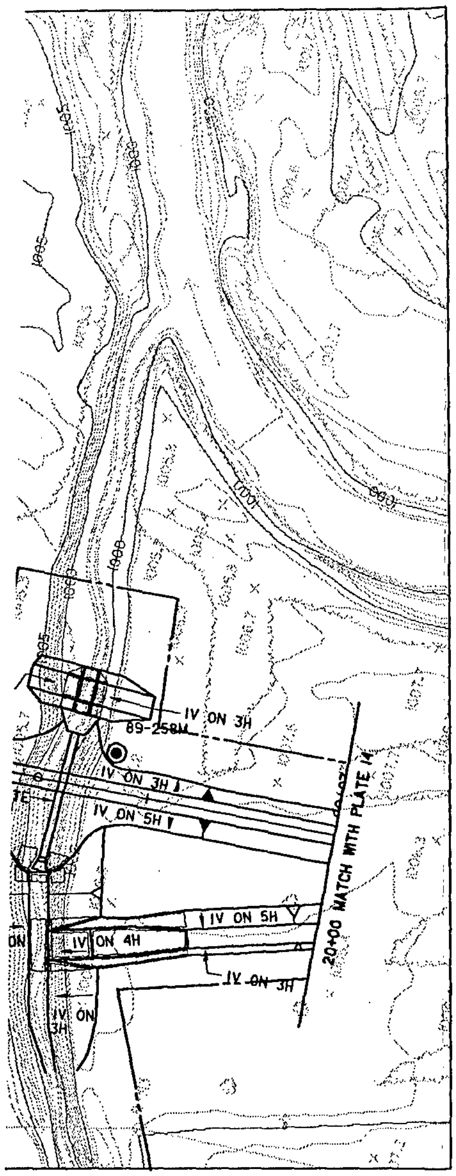


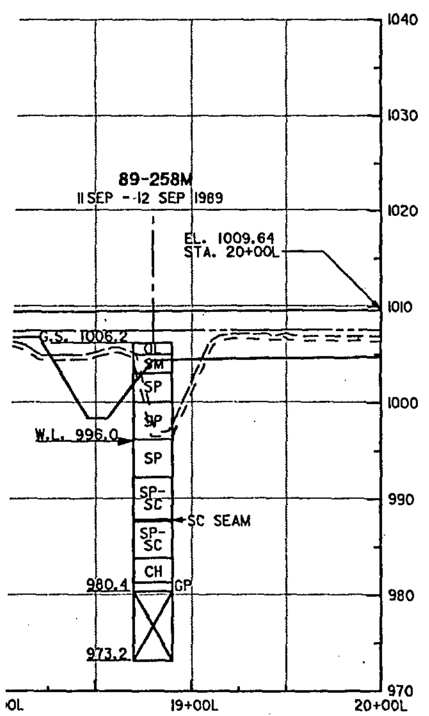


REFERENCES:

1. LEFT LEVEE SECTIONS
2. RCP CULVERT WITH FLAP GATE,
3. LANDSCAPE AND LIGHTING PLAN

SYMBOL	
AE APPROVING OFFICIAL:	FL
ED-D DESIGNED: KFB/CAS	
ED-D CHECKED: GVF	
ED-D DRAWN: KFB/dae	
ED-GH DESIGNED: FWC/DAC	
ED-GH CHECKED: SVD/MSM	CAD FILE NAME
DATE: MAY 92	SPEC NO:





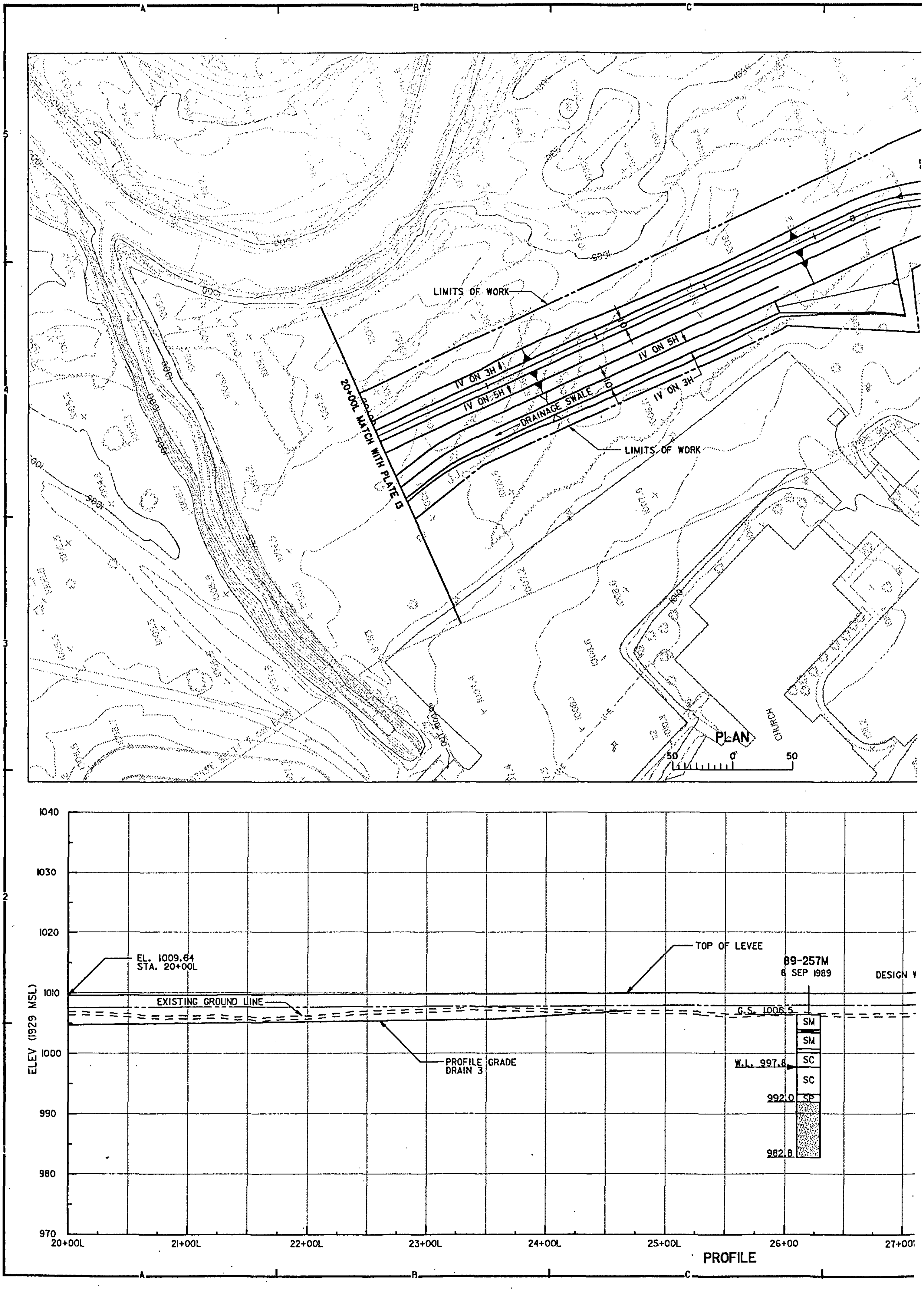
REFERENCES:

REFERENCES	PLATE NO.
1. LEFT LEVEE SECTIONS	27
2. RCP CULVERT WITH FLAP GATE, STA 18+50	35
3. LANDSCAPE AND LIGHTING PLAN	53

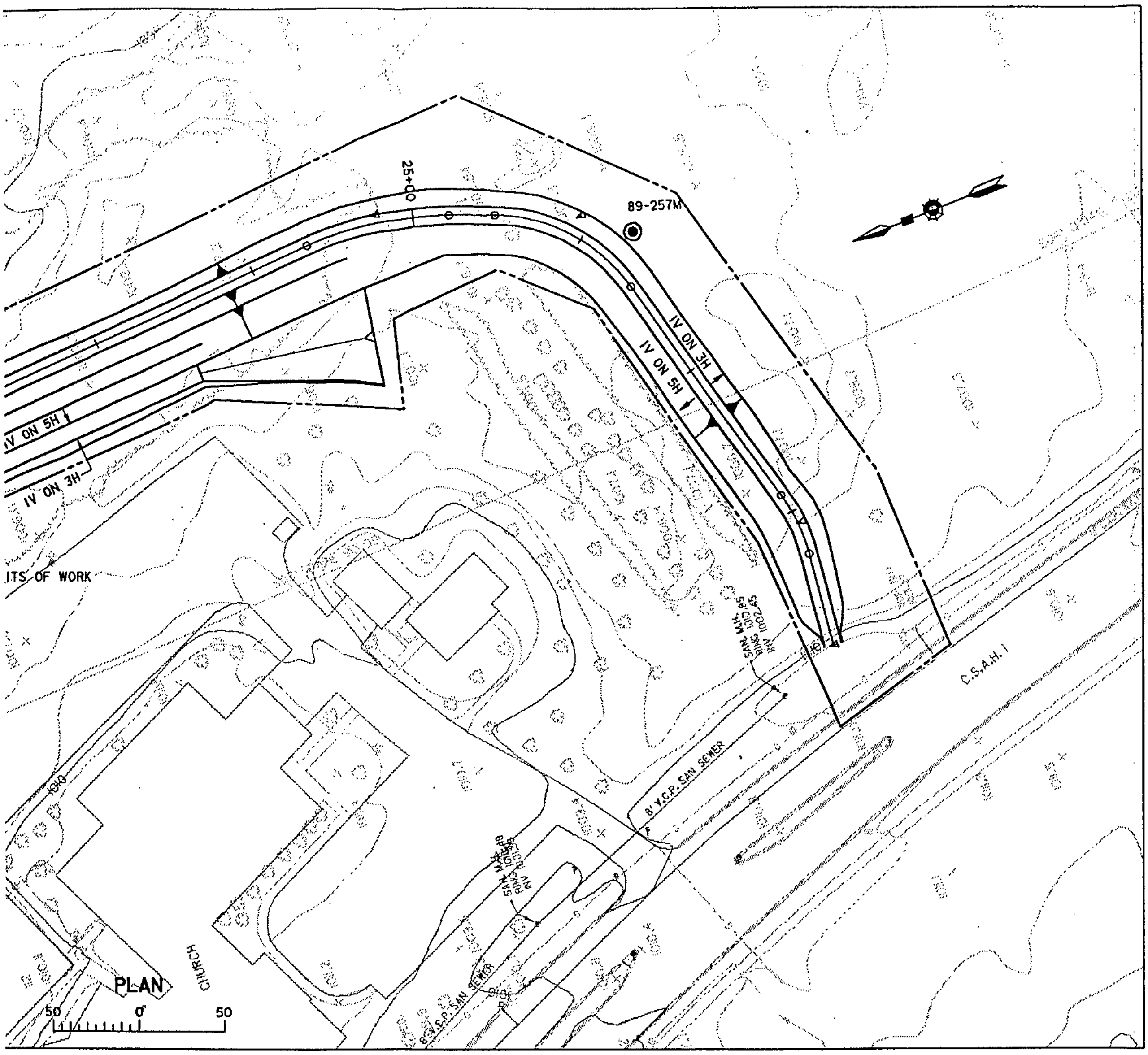
SYMBOL	DESCRIPTION	DATE	APPROVAL

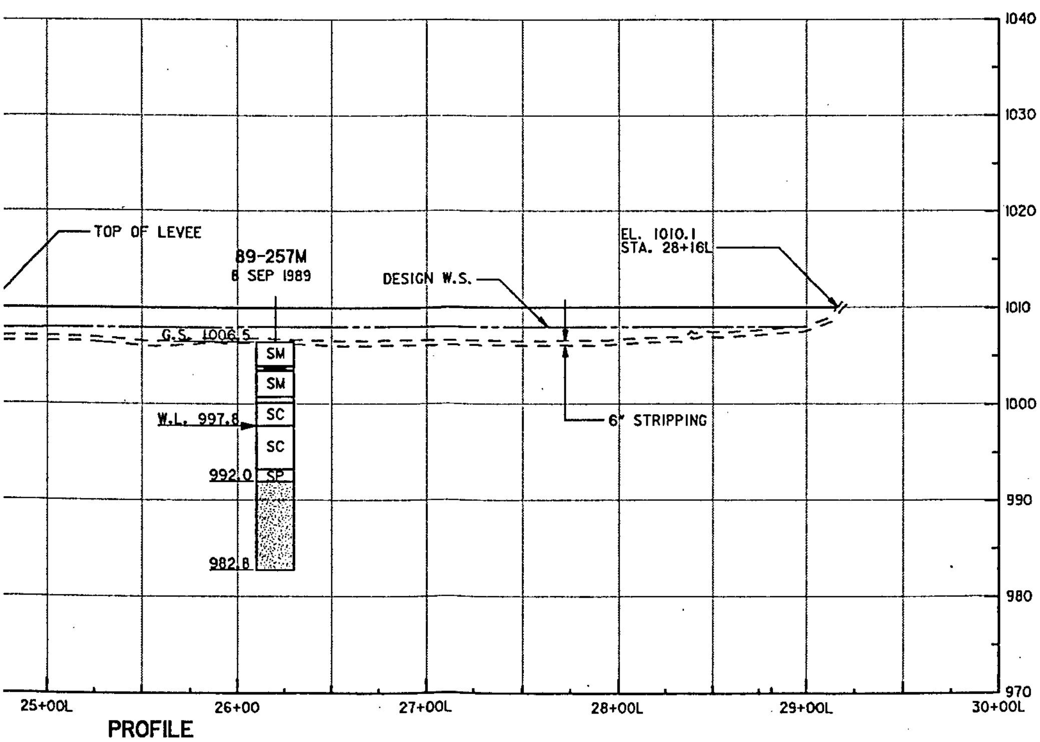
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:	DESIGN MEMORANDUM NO.6 FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER ROCHESTER, MINNESOTA **STAGE 4-BEAR CREEK** LEVEE PLAN AND PROFILE STATION 9+00L TO 20+00L	
ED-D DESIGNED: KFB/CAS		
ED-D CHECKED: GVF		
ED-D DRAWN: KFB/doe		
ED-GH DESIGNED: FWC/DAC		
ED-GH CHECKED: SVD/MSM	CAD FILE NAME: r4l0ll.dgn	DRAWING NUMBER: PLATE 13 — SHT 13 OF 53
DATE: MAY 92	SPEC NO:	



LIMITS OF WORK
1V ON 3H
1V ON 5H
1V ON 5H
1V ON 3H
DRAINAGE SWALE
LIMITS OF WORK
20+00L MATCH WITH PLATE 13
CHURCH
PLAN
50
0
50
1040
1030
1020
1010
1000
990
980
970
ELEV (1929 MSL)
EL. 1009.64
STA. 20+00L
EXISTING GROUND LINE
TOP OF LEVEE
89-257M
8 SEP 1989
DESIGN
G.S. 1006.5
SM
SM
W.L. 997.8
SC
SC
992.0
SP
982.8
PROFILE GRADE
DRAIN 3
20+00L
21+00L
22+00L
23+00L
24+00L
25+00L
26+00
27+00
PROFILE





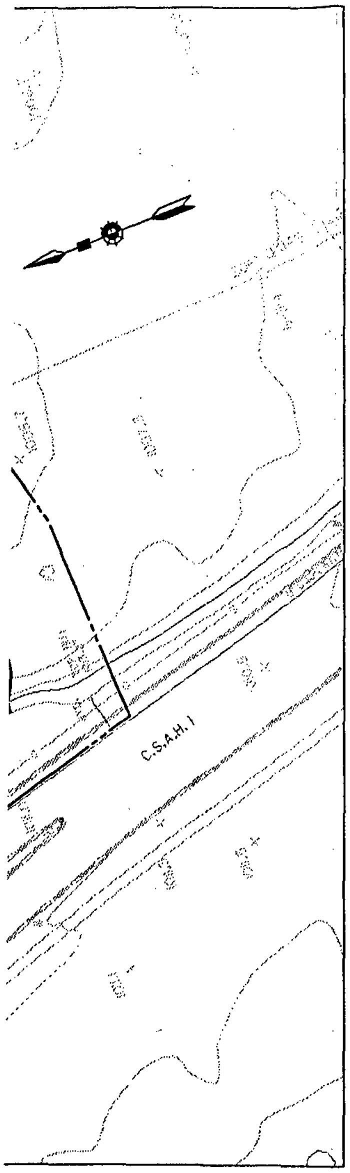
REFERENCES:

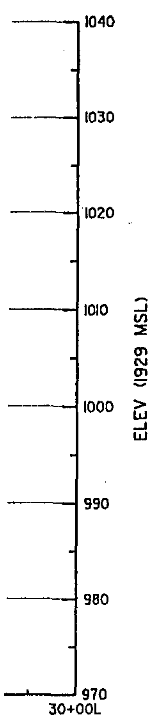
1. LEFT LEVEE SECTIONS

SYMBOL

AE APPROVING OFFICIAL:

ED-D	DESIGNED: KFB/CAS	
	CHECKED: GVF	
	DRAWN: KFB/dae	
ED-GH	DESIGNED: FWC/DAC	
	CHECKED: SVD/MSM	CAD FILE
DATE: MAY 92		SPEC NO:





REFERENCES: | **PLATE NO.**
1. LEFT LEVEE SECTIONS — 27

SYMBOL	DESCRIPTION	DATE	APPROVAL

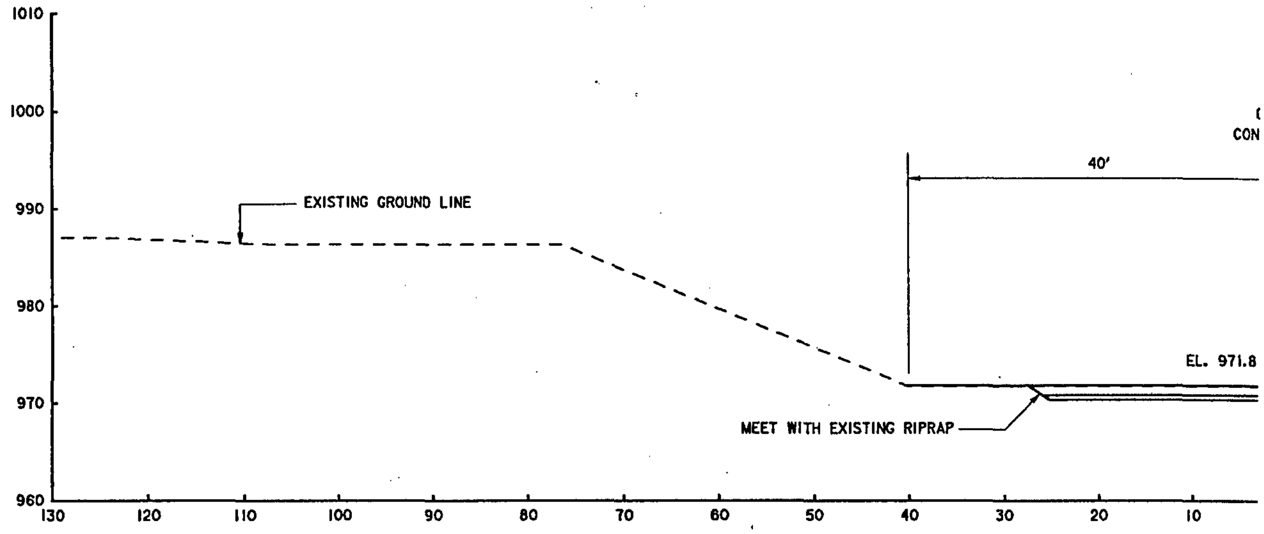
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

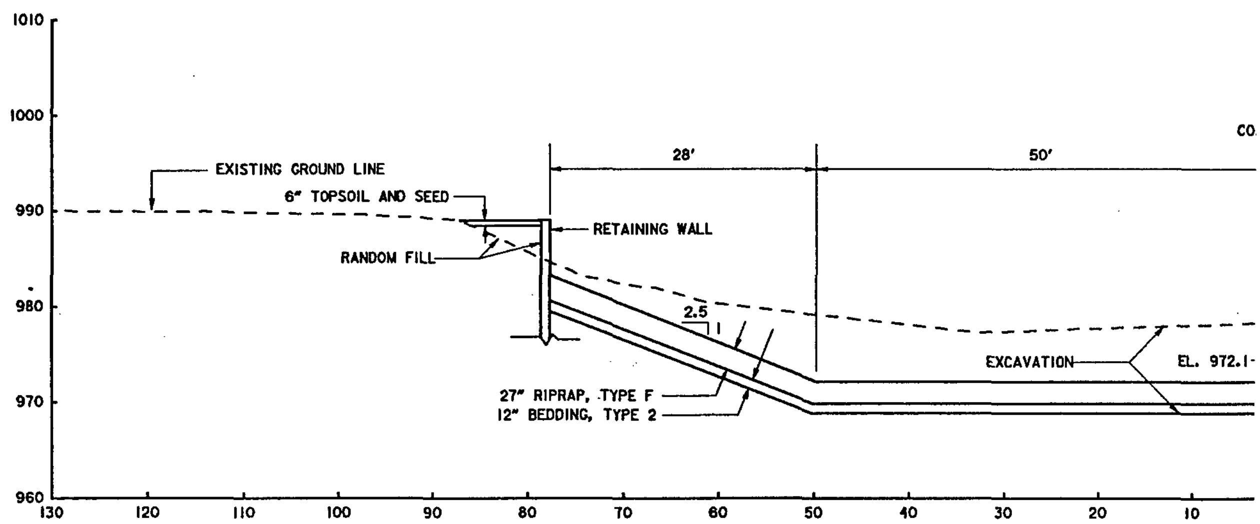
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LEVEE PLAN AND PROFILE
STATION 20+00L TO 29+00L

ED-D	DESIGNED: KFB/CAS
ED-D	CHECKED: GVF
ED-D	DRAWN: KFB/dae
ED-CH	DESIGNED: FWC/DAC
ED-CH	CHECKED: SVD/MSM
	DATE: MAY 92

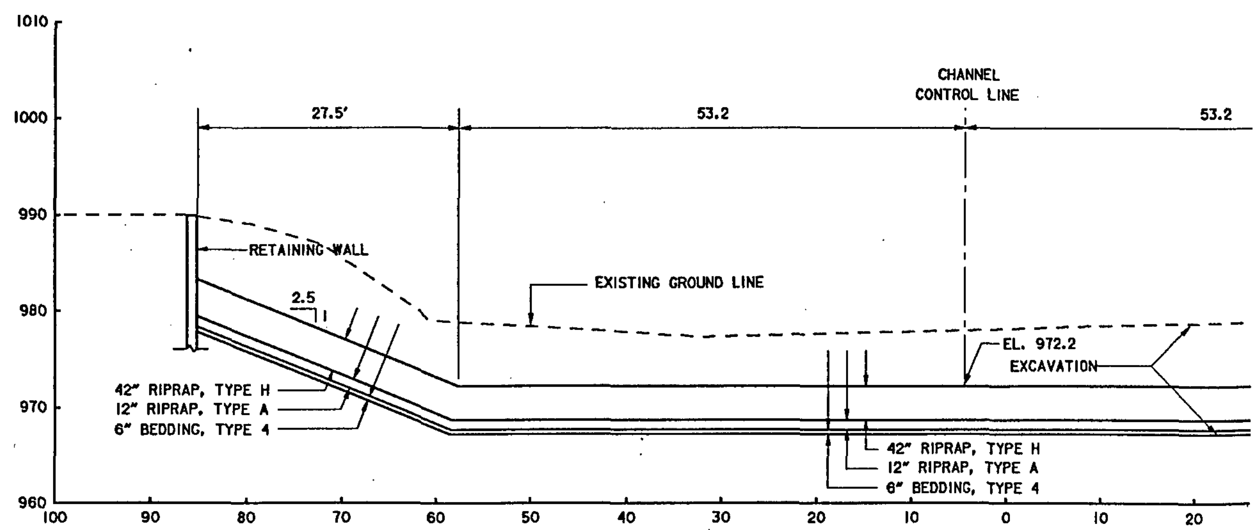
CAD FILE NAME: r4lol2.dgn
SPEC NO:
DRAWING NUMBER: PLATE 14
SHT 14 OF 53



SECTION
STATION 3+

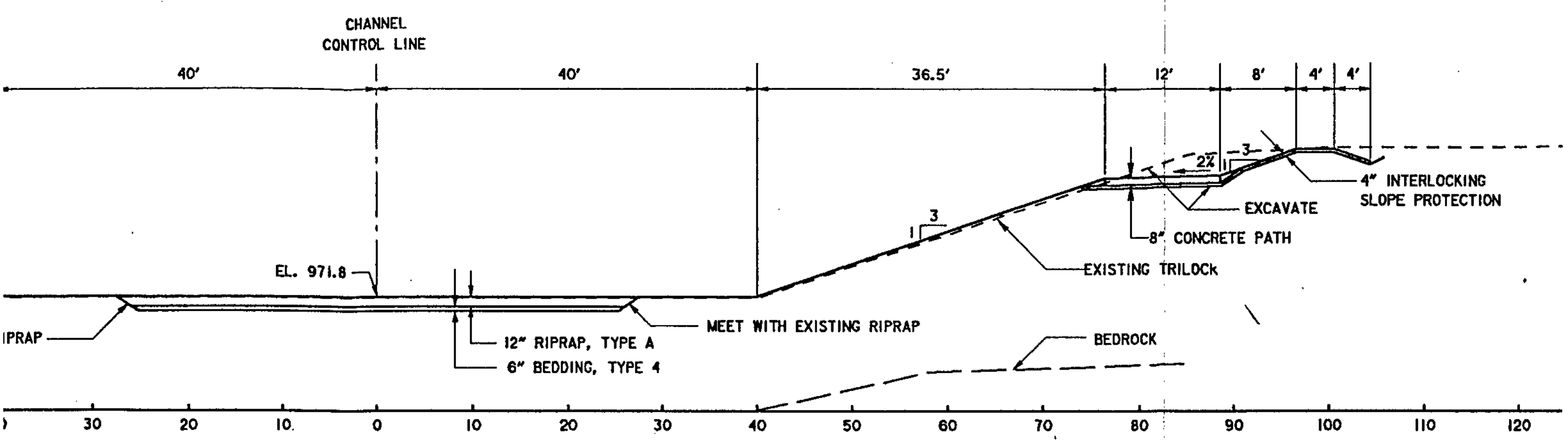


SECTION
STATION 5+



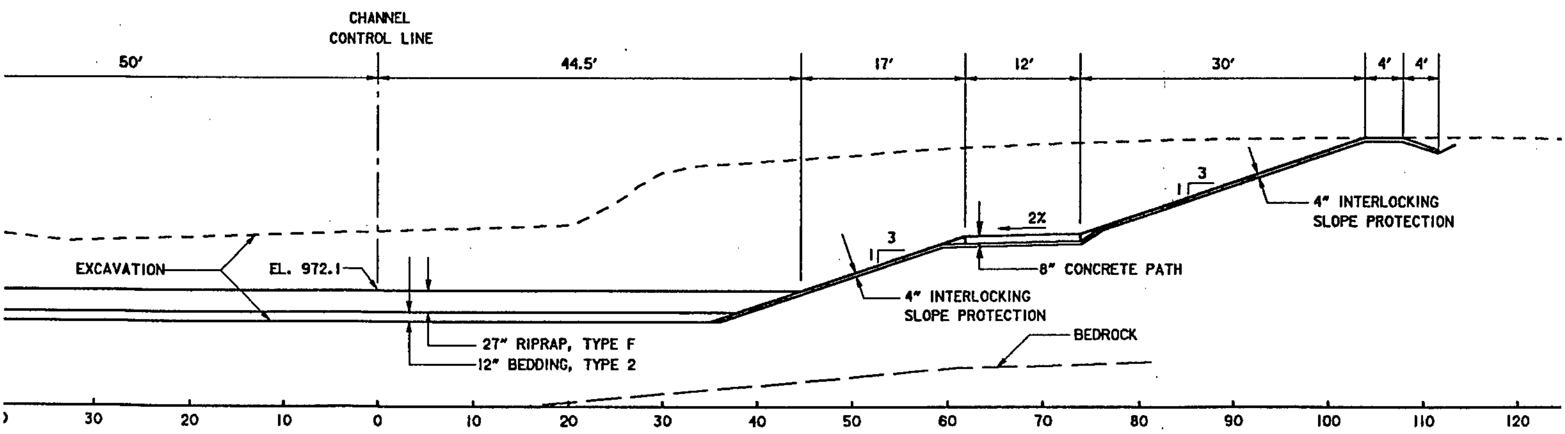
SECTION
STATION 5+71

3



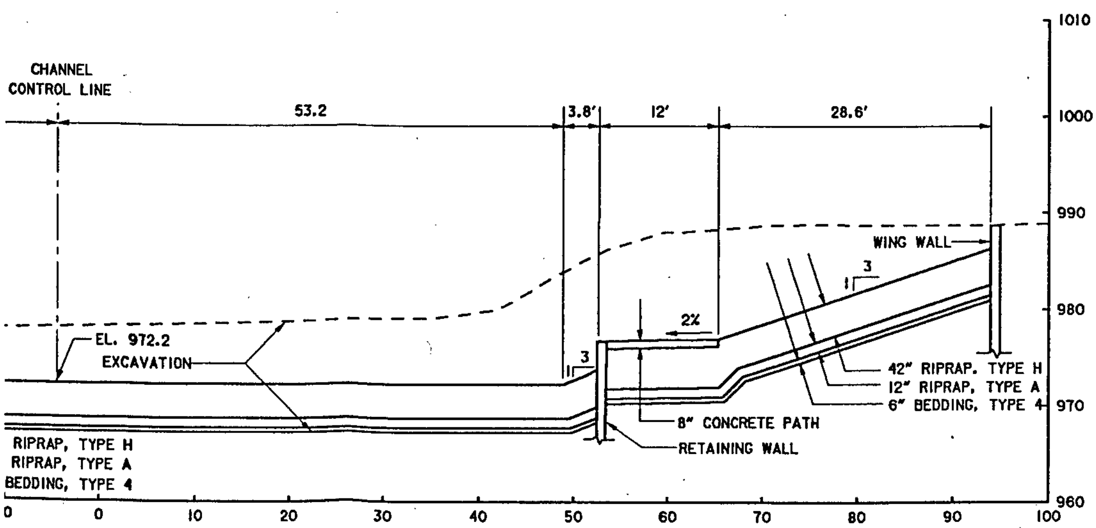
SECTION
STATION 3+71

1



SECTION
STATION 5+21

2



CTION
ATION 5+71

3

SYMBOL	DESCRIPT

AE APPROVING OFFICIAL:

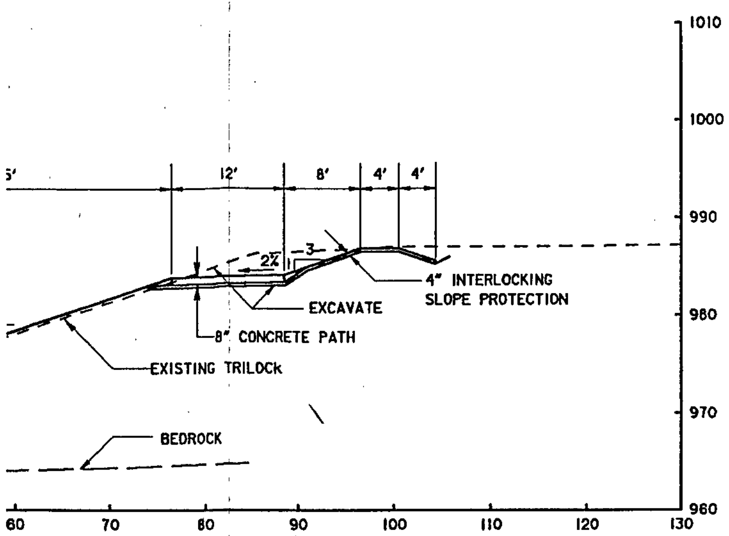
FLOOD CON

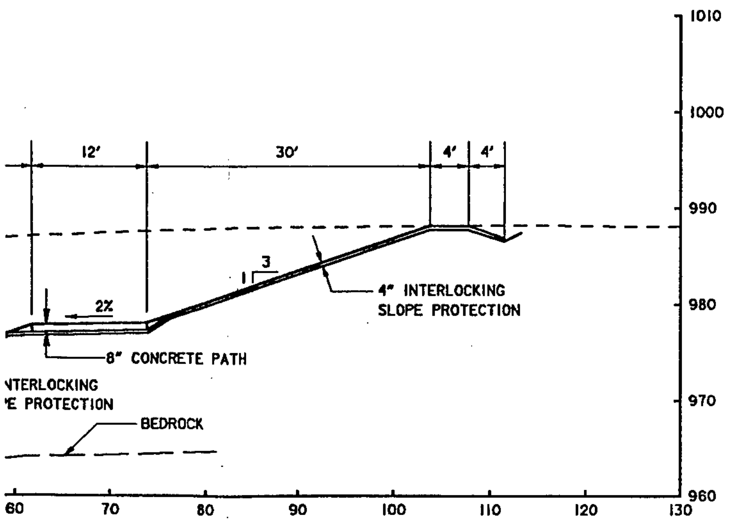
ST

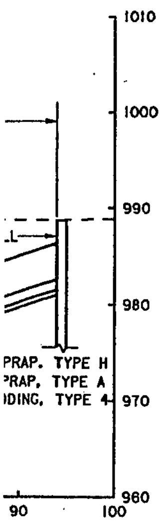
ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM
DATE: MAY 92		

CAD FILE NAME: r4xs01.

SPEC NO:







SYMBOL	DESCRIPTION	DATE	APPROVAL

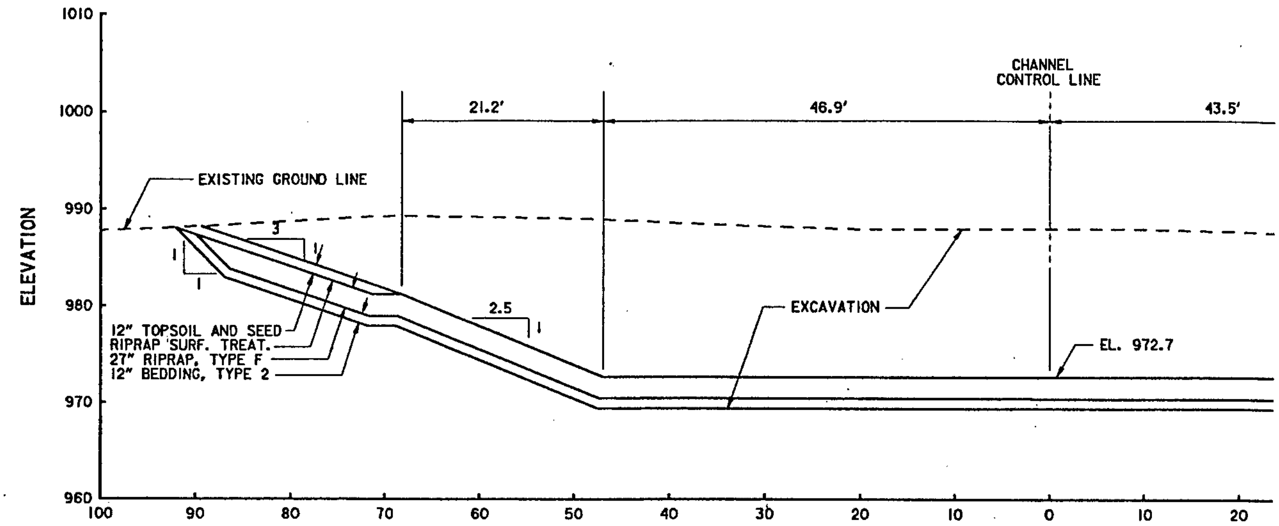
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

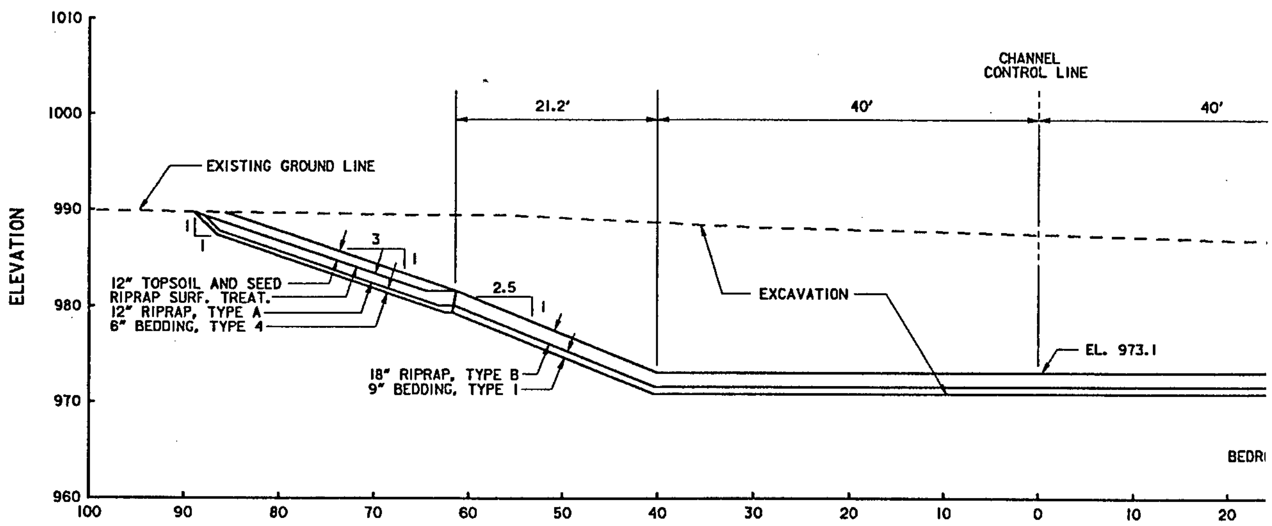
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
CHANNEL SECTIONS 1-3
STATION 3+71 TO 5+71

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM

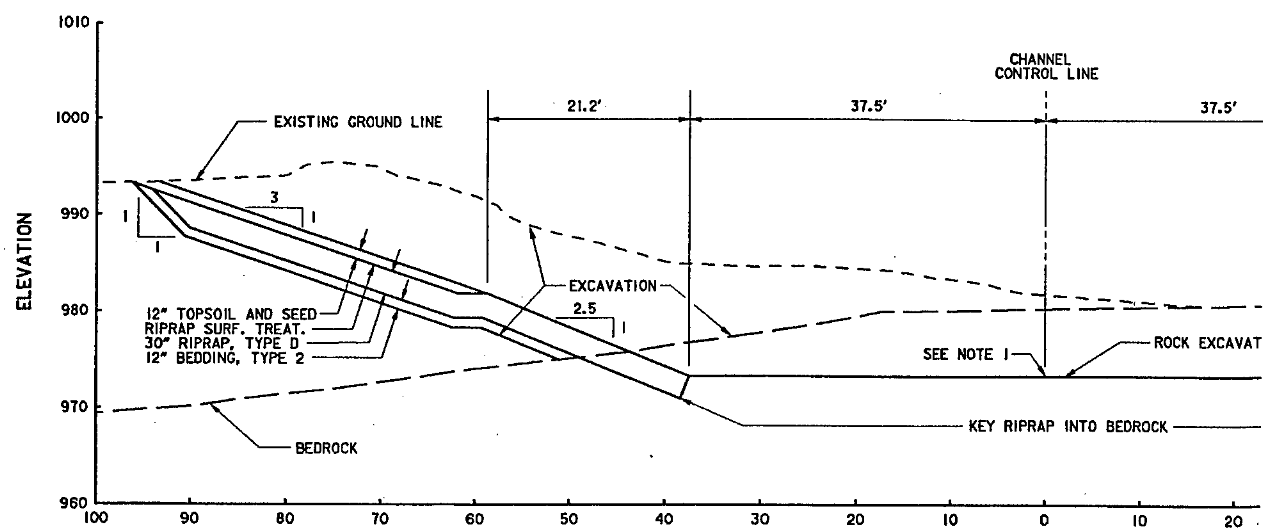
DATE: MAY 92
CAD FILE NAME: r4xs01.dgn
SPEC NO:
DRAWING NUMBER: PLATE 15
SHT 15 OF 53



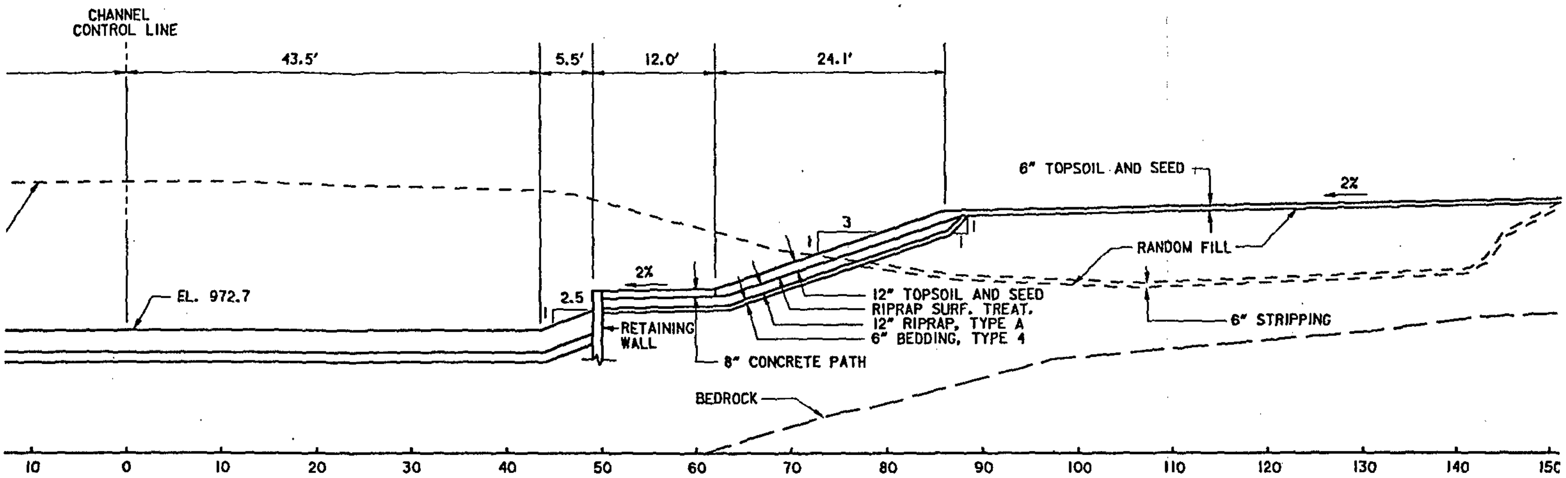
SECTION
STATION 8+00
4



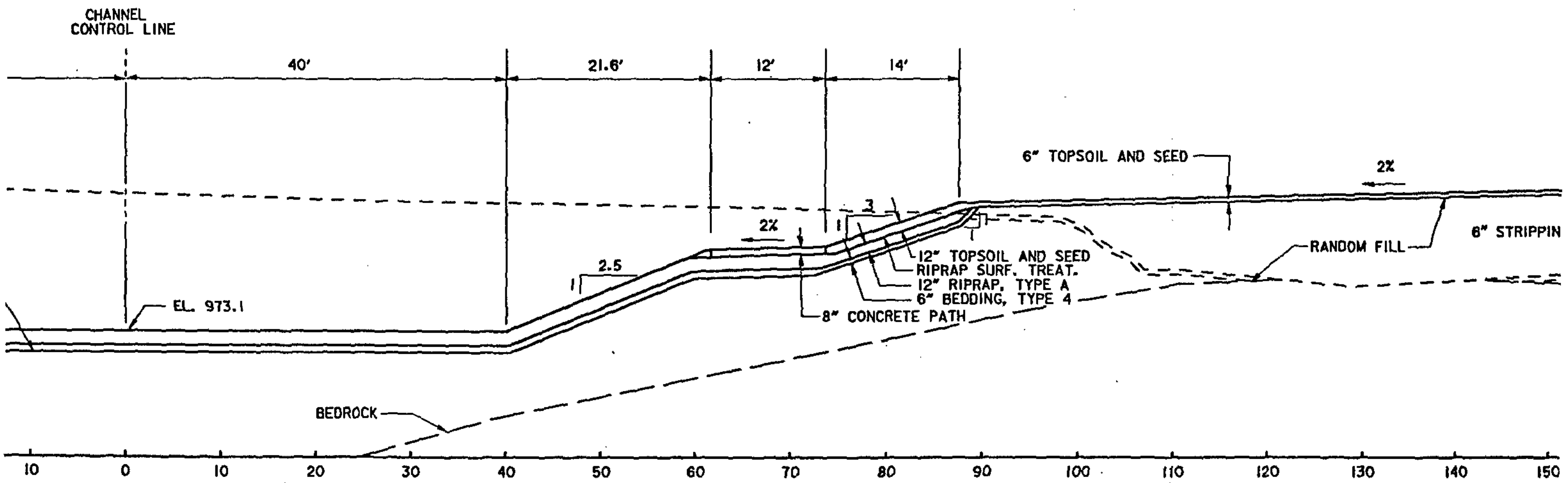
SECTION
STATION 10+00
5



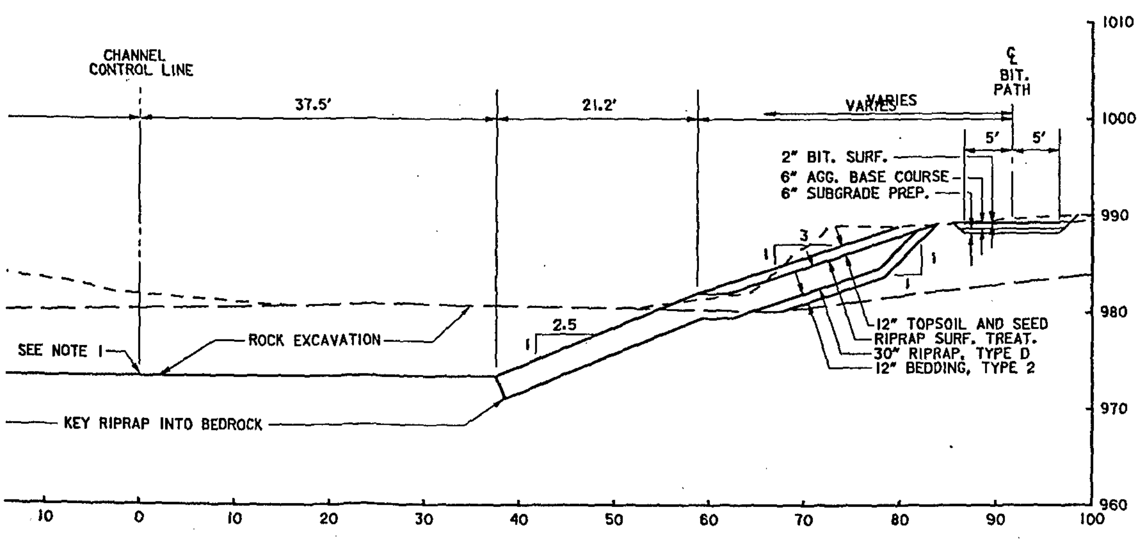
TYPICAL SECTION
STATION 11+65 TO 11+90
6



SECTION 4
STATION 8+00



ECTION 5
TATION 10+00



TYPICAL SECTION 6
STATION 11+65 TO 11+90

NOTES:

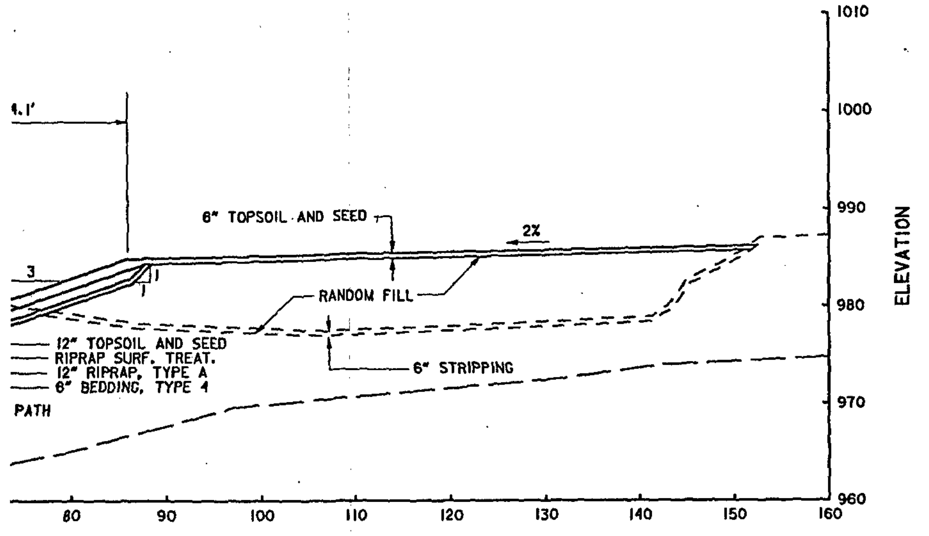
1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACE[D] OVER RIPRAP.

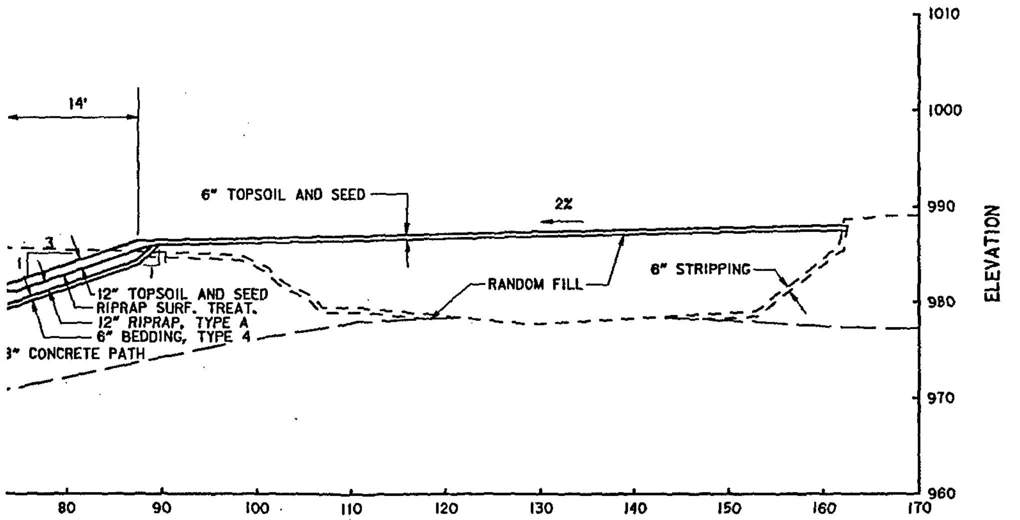
SYMBOL	DESCR

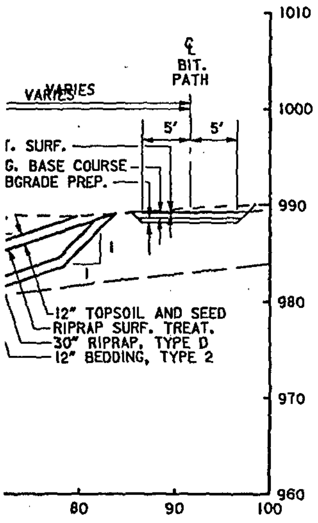
AE APPROVING OFFICIAL:

FLOOD C

ED-D	DESIGNED: KFB/CAS	
ED-D	CHECKED: GVF	
ED-D	DRAWN: KFB/DAE	
ED-GH	DESIGNED: FWC/DAC	
ED-GH	CHECKED: SVD/MSM	CAD FILE NAME: r4xs
DATE: MAY 92		SPEC NO:







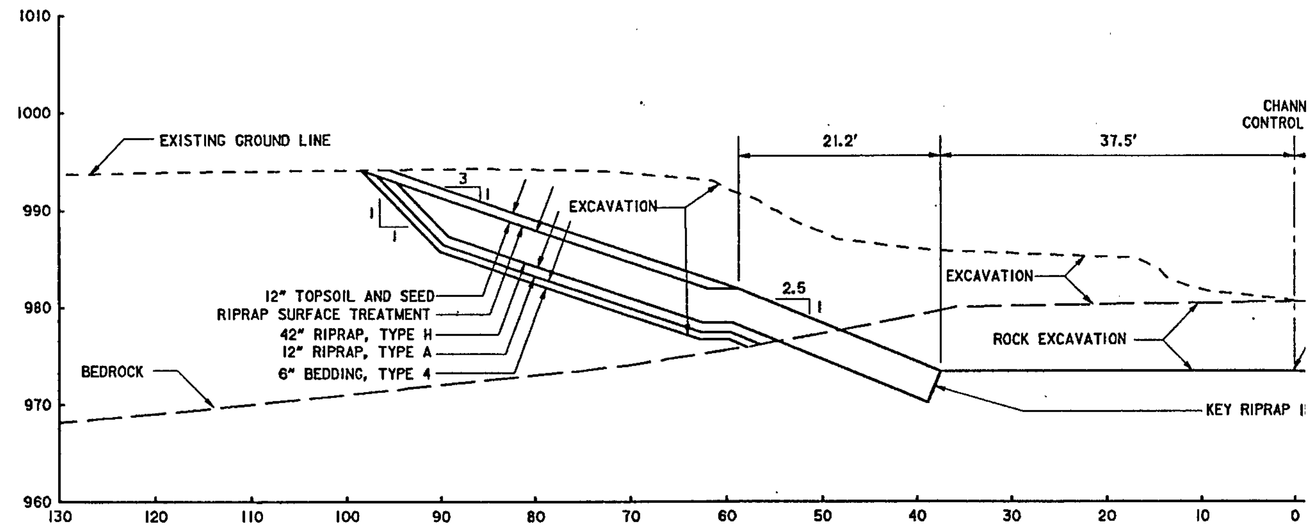
NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP.

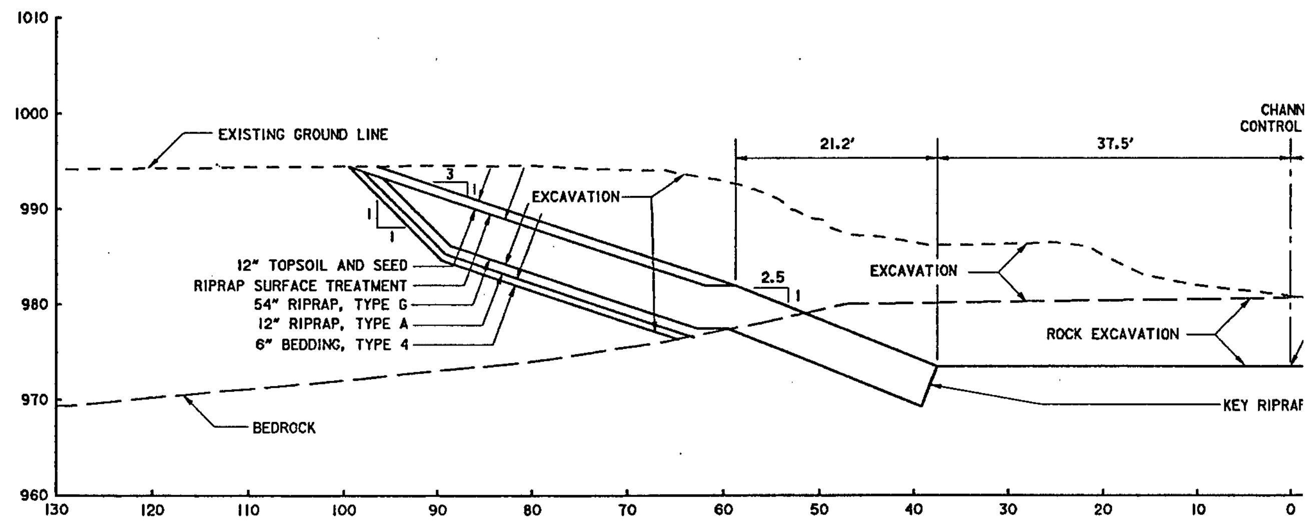
SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

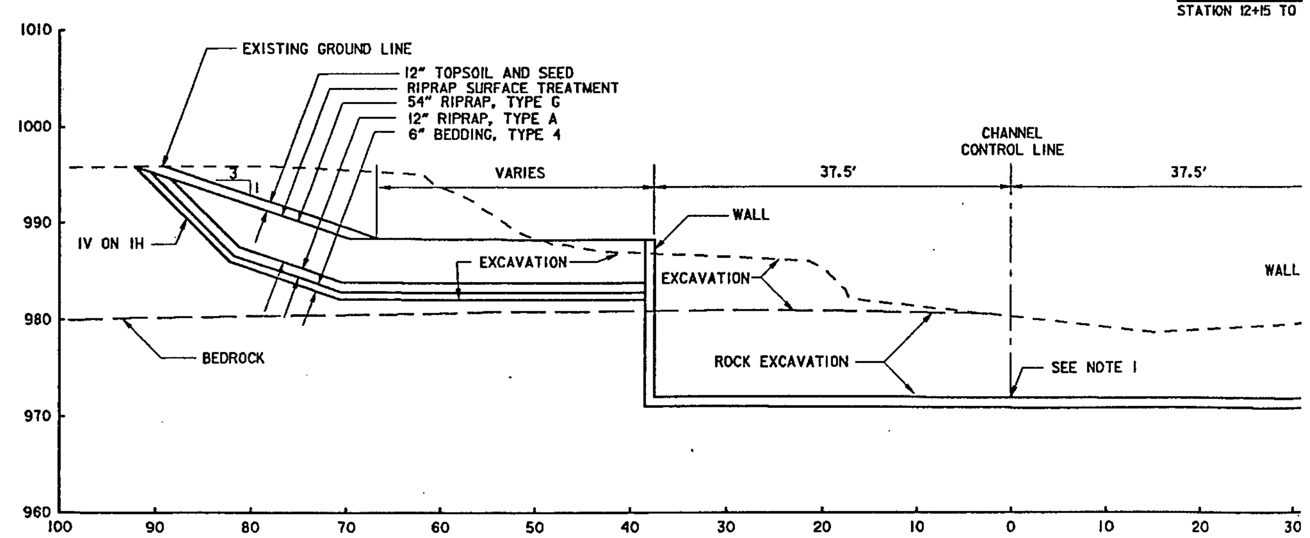
AE APPROVING OFFICIAL:	DESIGN MEMORANDUM NO.6 FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER ROCHESTER, MINNESOTA STAGE 4-BEAR CREEK CHANNEL SECTIONS 4-6 STATION 8+00 TO 11+90
ED-D DESIGNED: KFB/CAS	
ED-D CHECKED: GVF	
ED-D DRAWN: KFB/DAE	
ED-CH DESIGNED: FWC/DAC	
ED-CH CHECKED: SVD/MSM	CAD FILE NAME: r4xs02.dgn — DRAWING NUMBER: PLATE 16 — SHT 16
DATE: MAY 92	SPEC NO: — OF 53



TYPICAL SECTIO
STATION 11+90 TO

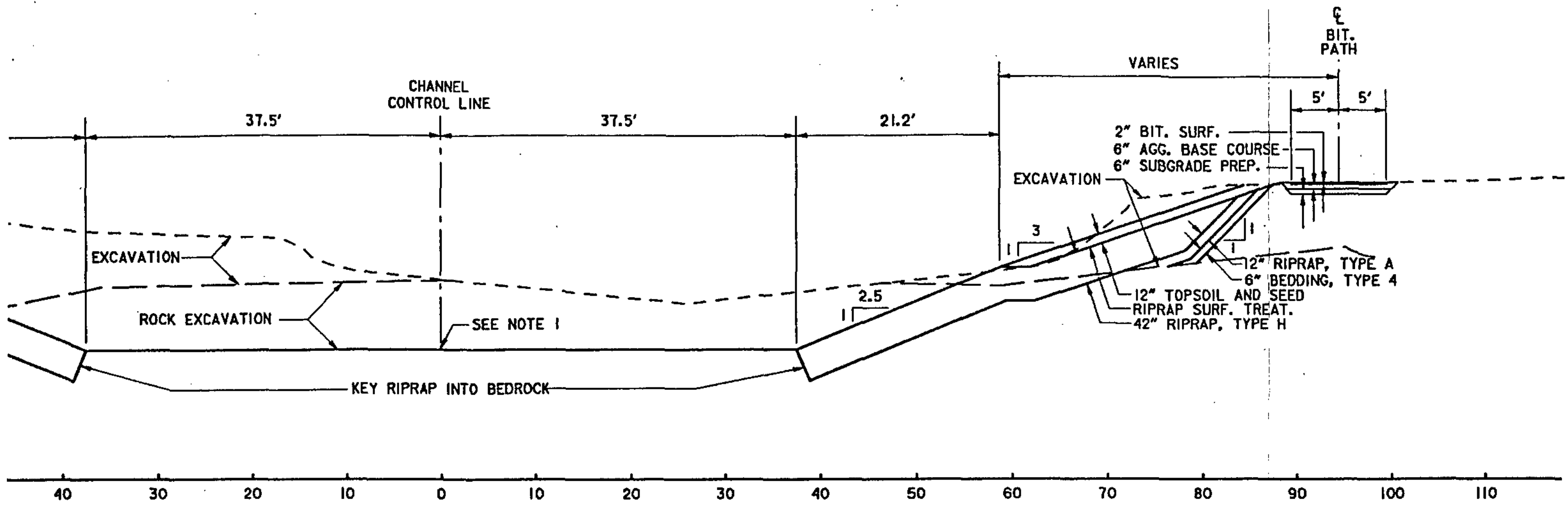


TYPICAL SECTIO
STATION 12+15 TO

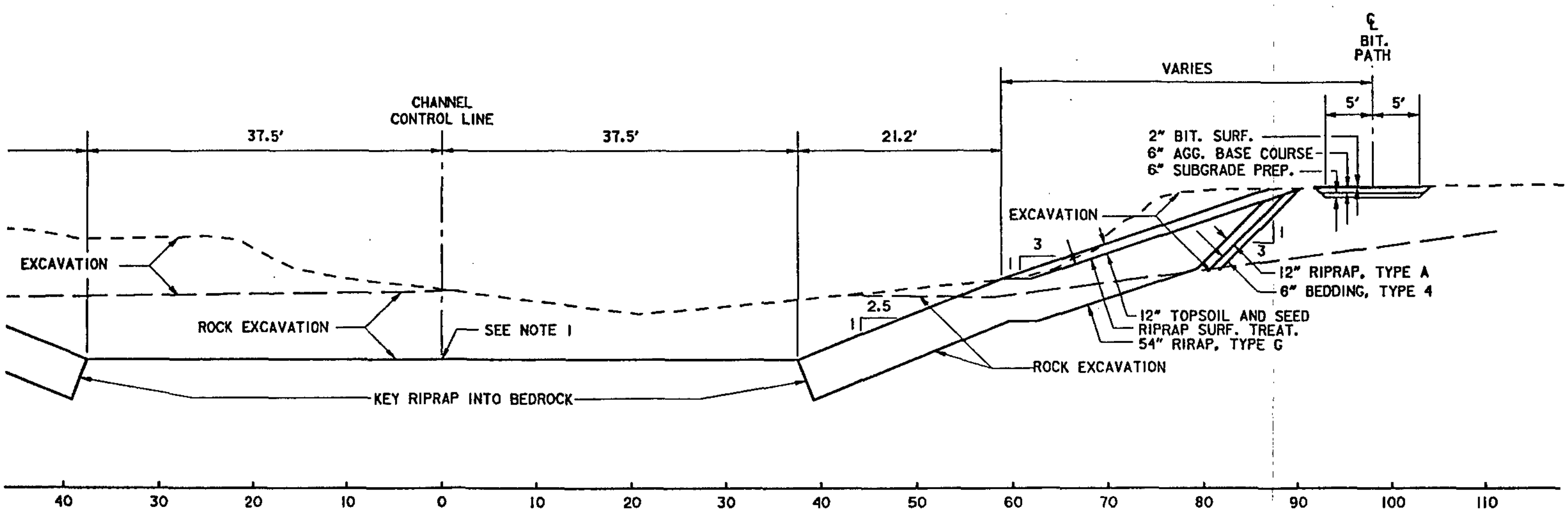


TYPICAL SECTION
STATION 12+65 TO 13+00

9



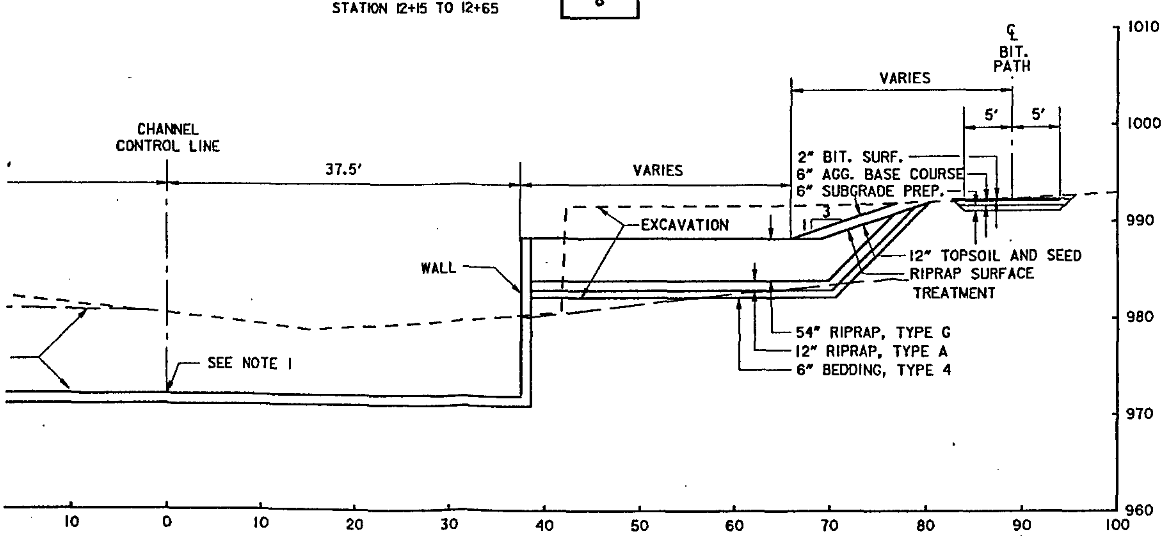
TYPICAL SECTION 7
STATION 11+90 TO 12+15



TYPICAL SECTION 8
STATION 12+15 TO 12+65

NOTES:

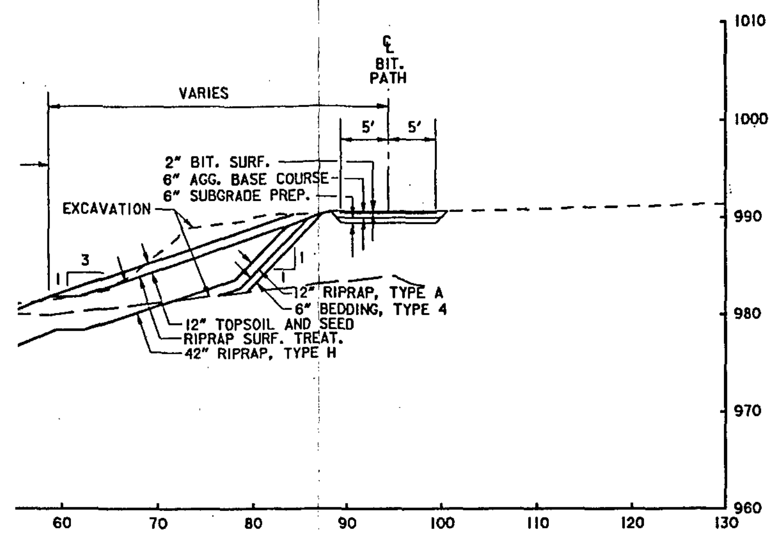
1. ELEVATION VARIES - SE
2. RIPRAP SURFACE TREAT
REQUIRED BETWEEN TOP

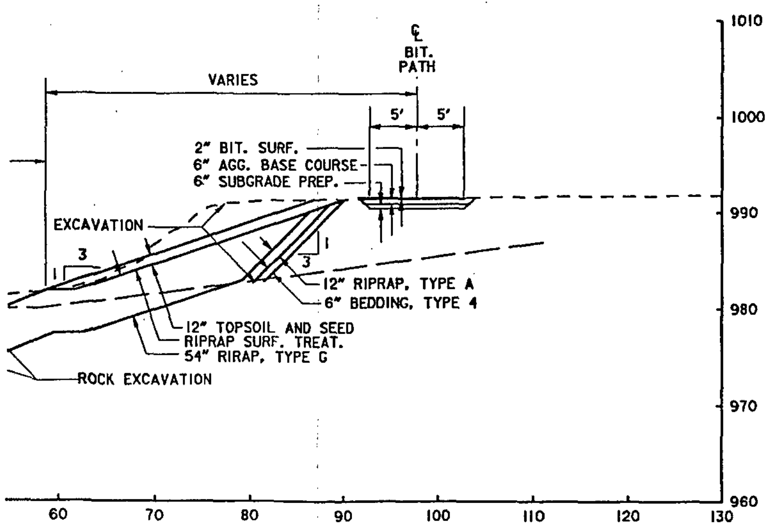


TYPICAL SECTION 9
STATION 12+65 TO 13+00

SYMBOL	
AE APPROVING OFFICIAL:	
ED-D DESIGNED:	KFB/CAS
ED-D CHECKED:	GVF
ED-D DRAWN:	KFB/dae
ED-GH DESIGNED:	FWC/DAC
ED-GH CHECKED:	SVD/MSM
DATE:	MAY 92

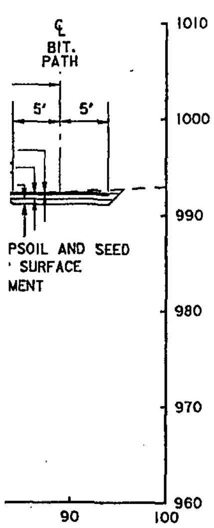
CAD FIL
SPEC N





NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED BETWEEN TOPSOIL AND RIPRAP



SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
CHANNEL SECTIONS 7-9
STATION 11+90 TO 13+00

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM

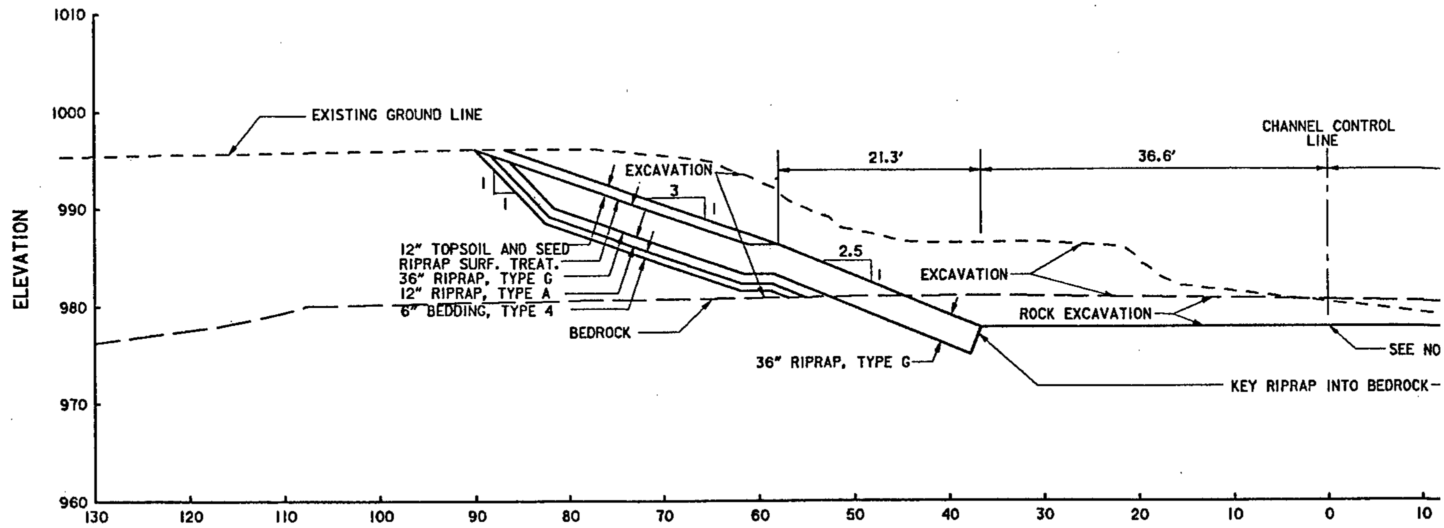
DATE: MAY 92

CAD FILE NAME: r4xs03.dgn

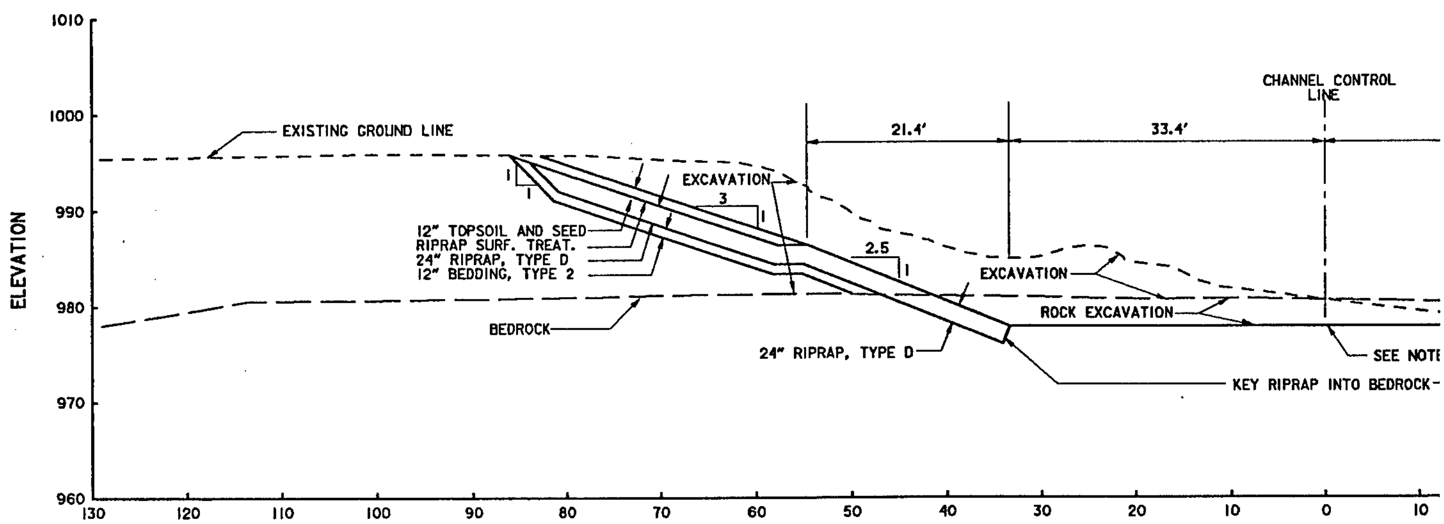
SPEC NO:

DRAWING NUMBER: PLATE 17

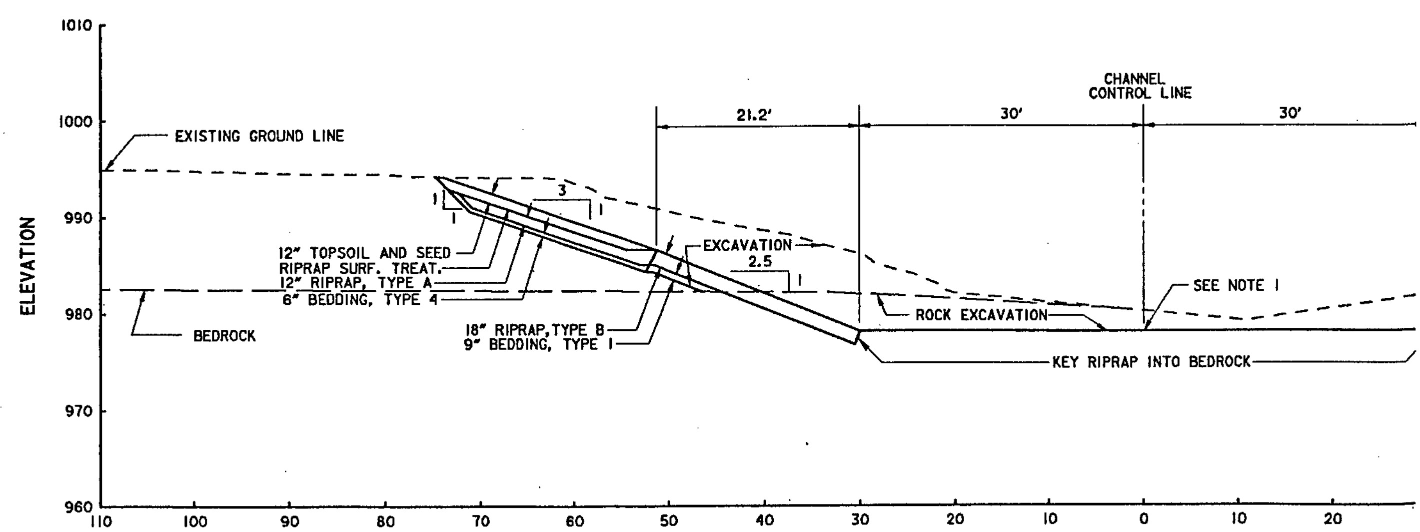
SHT 17 OF 53



TYPICAL SECTION
STATION 13+00 TO 13+25

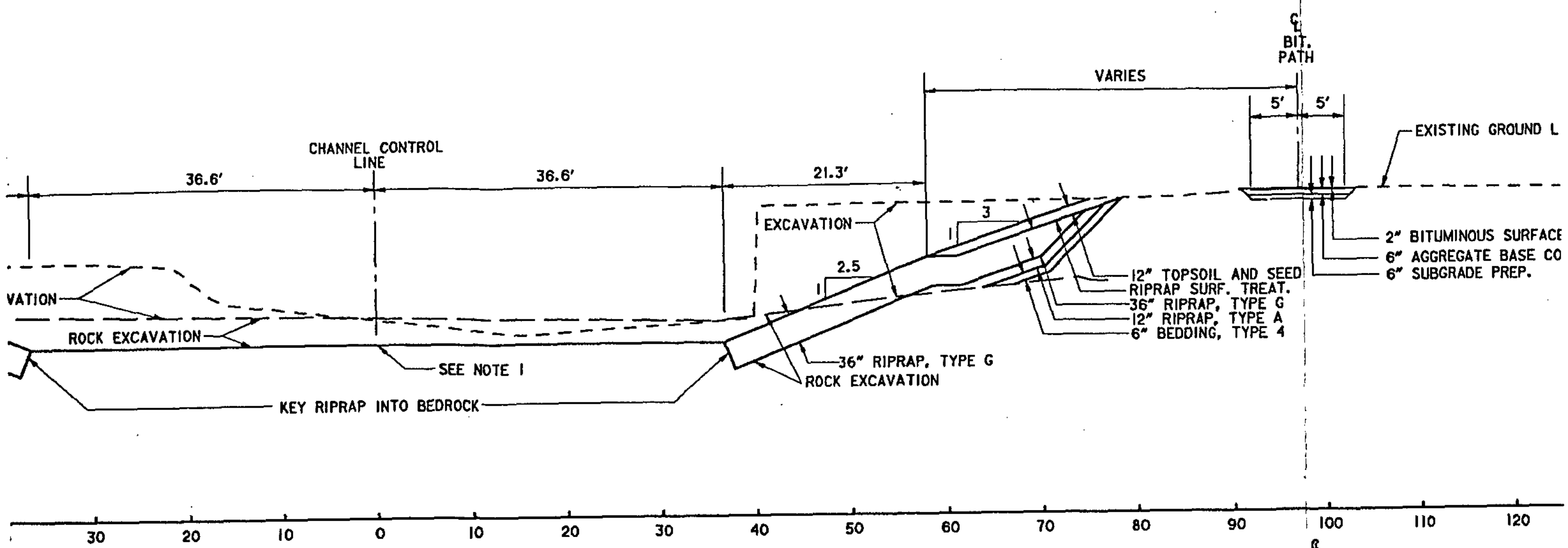


TYPICAL SECTION
STATION 13+25 TO 13+50

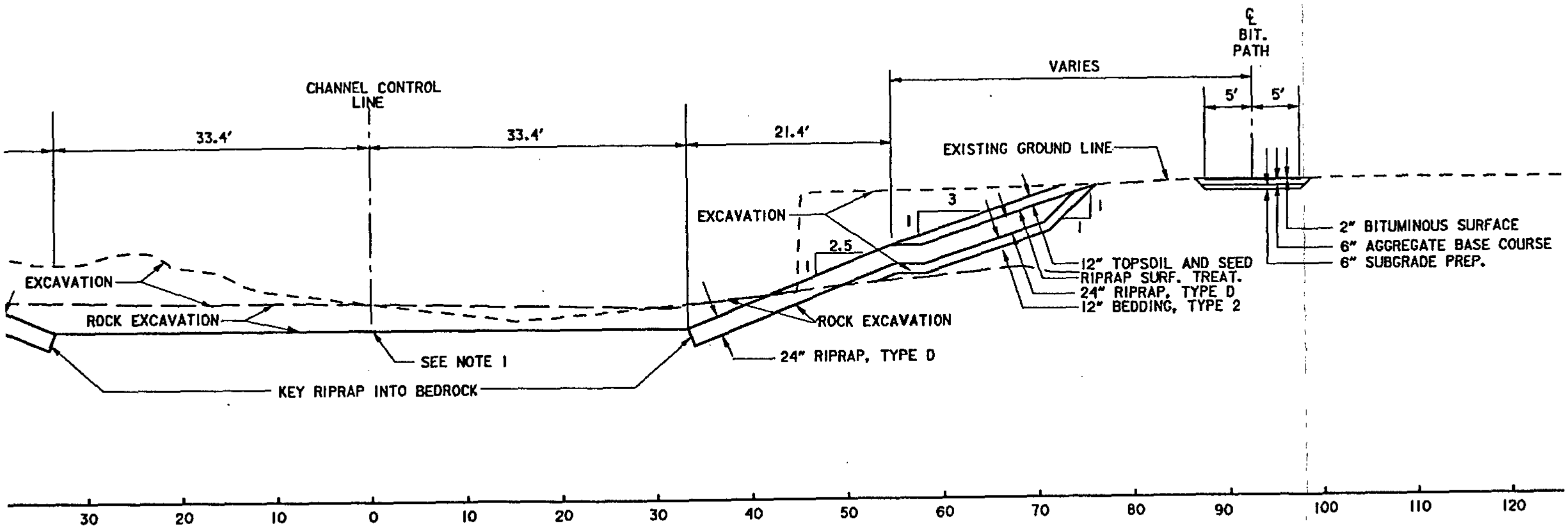


TYPICAL SECTION
STATION 13+50 TO 14+90

12



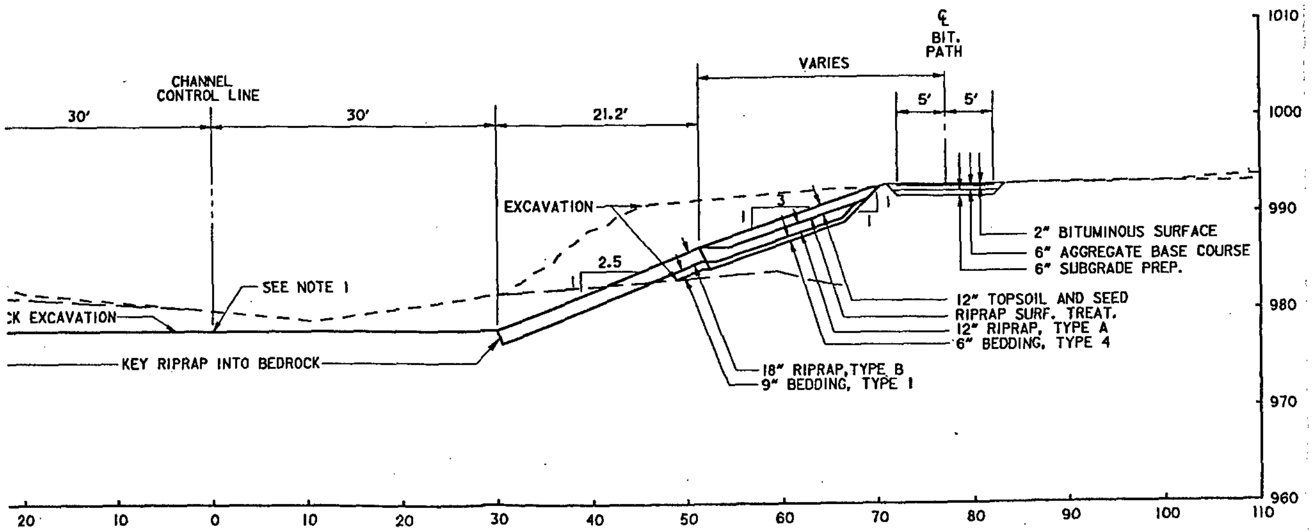
TYPICAL SECTION **10**
STATION 13+00 TO 13+25



TYPICAL SECTION **11**
STATION 13+25 TO 13+50

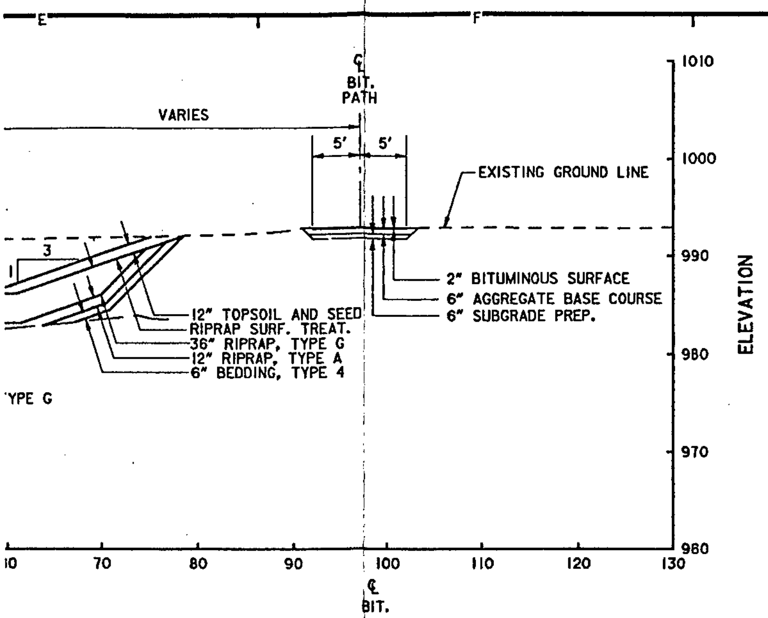
NOTES:

1. ELEVATION VARIES -
2. RIPRAP SURFACE TRE REQUIRED BETWEEN T RIPRAP.

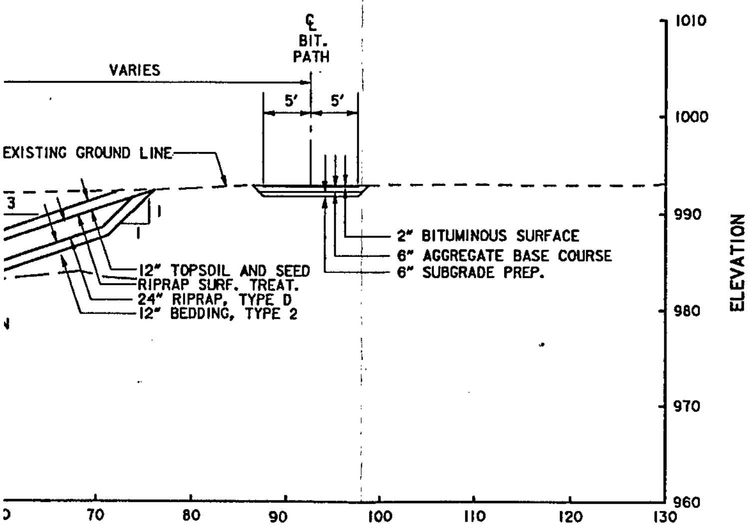


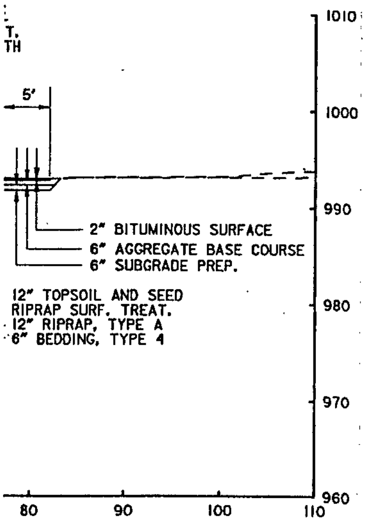
TYPICAL SECTION **12**
STATION 13+50 TO 14+90

SYMBOL	
AE APPROVING OFFICIAL:	
ED-D DESIGNED:	KFB/CAS
ED-D CHECKED:	GVF
ED-D DRAWN:	KFB/DAE
ED-GH DESIGNED:	FWC/DAC
ED-GH CHECKED:	SVD/MSM
DATE: MAY 92	



℄ BIT.





NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED BETWEEN TOPSOIL AND RIPRAP.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

STAGE 4-BEAR CREEK
CHANNEL SECTIONS 10-12
STATION 13+00 TO 14+90

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/DAE
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM

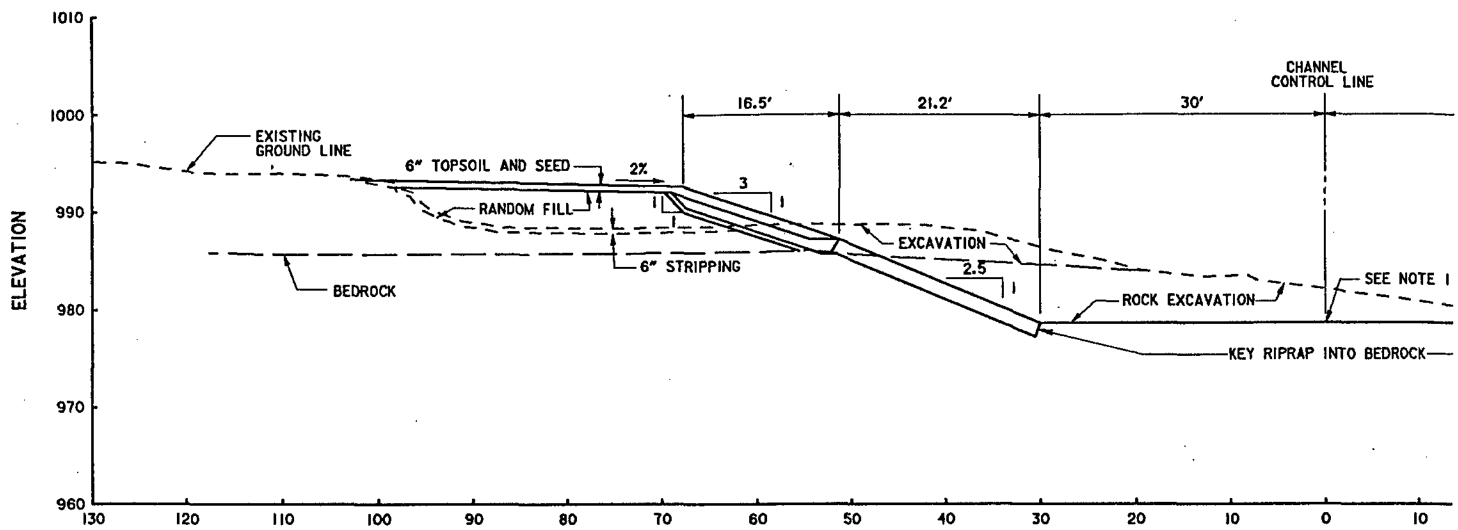
DATE: MAY 92

CAD FILE NAME: r4xs04.dgn

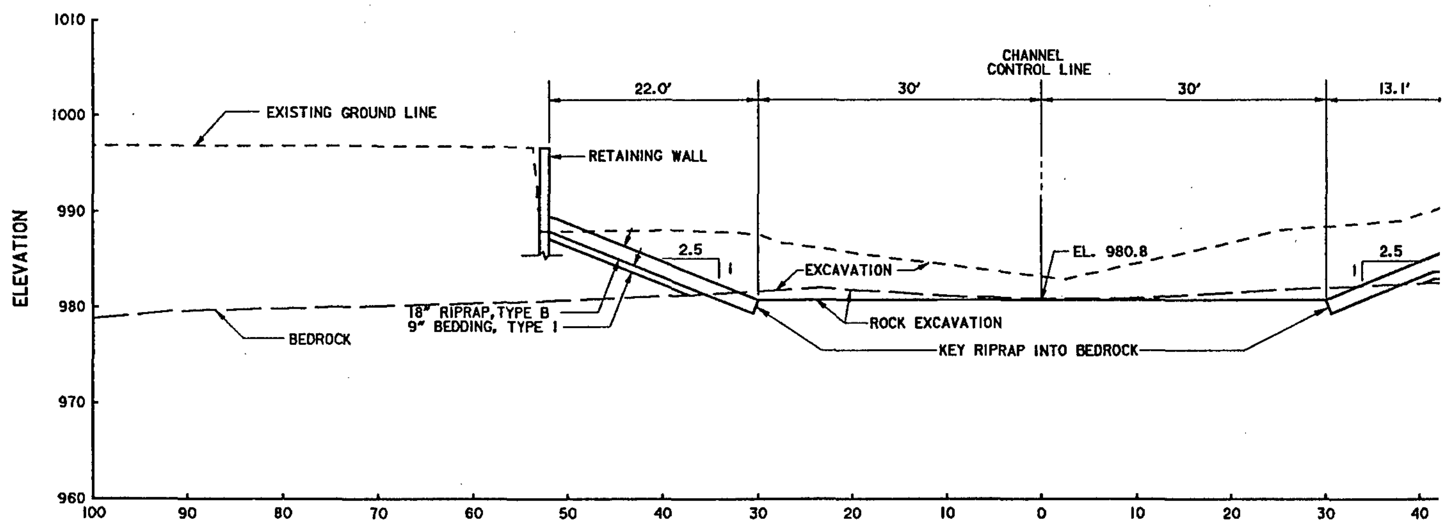
SPEC NO:

DRAWING NUMBER: PLATE 18

SHT 18 OF 53

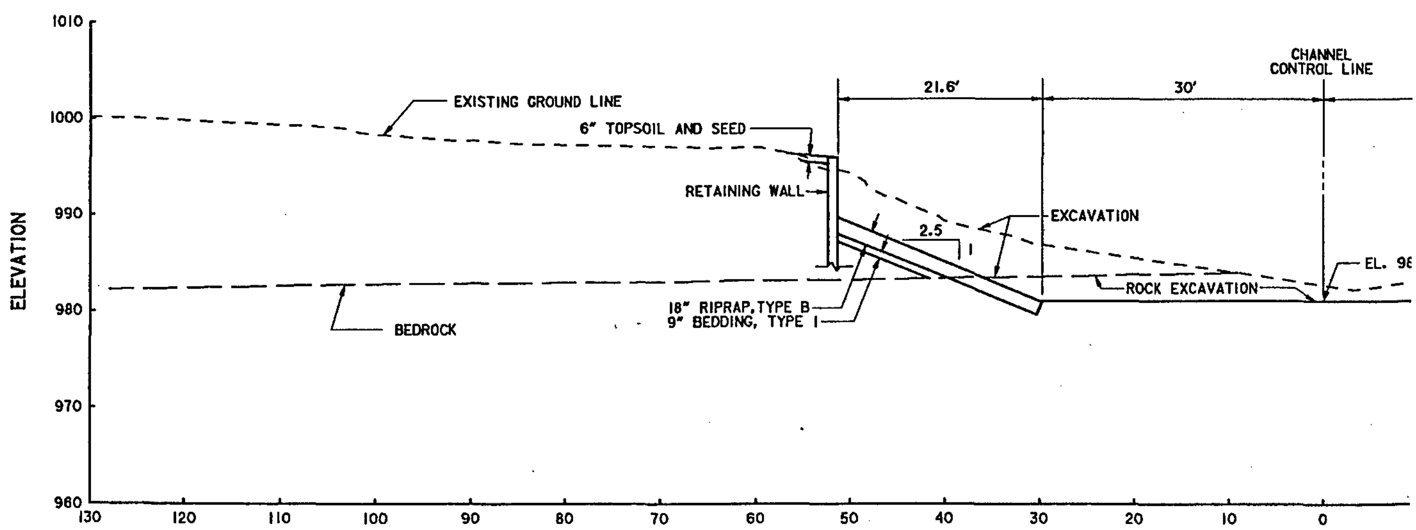


TYPICAL SECTION
STATION 14+90 TO 21+15

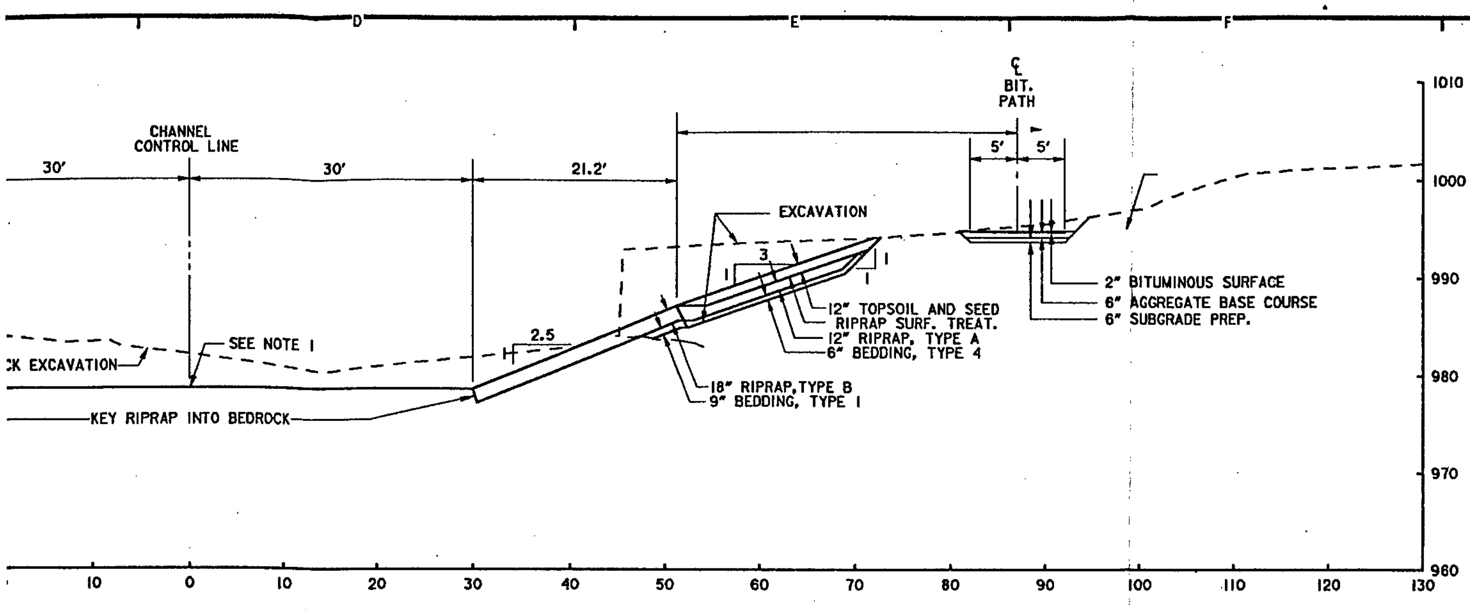


SECTION
STATION 22+90

14

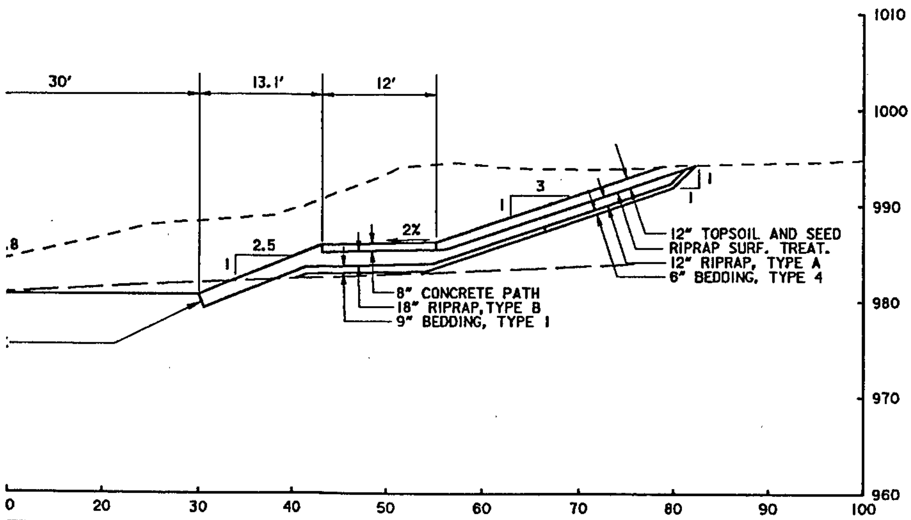


SECTION
STATION 23+75

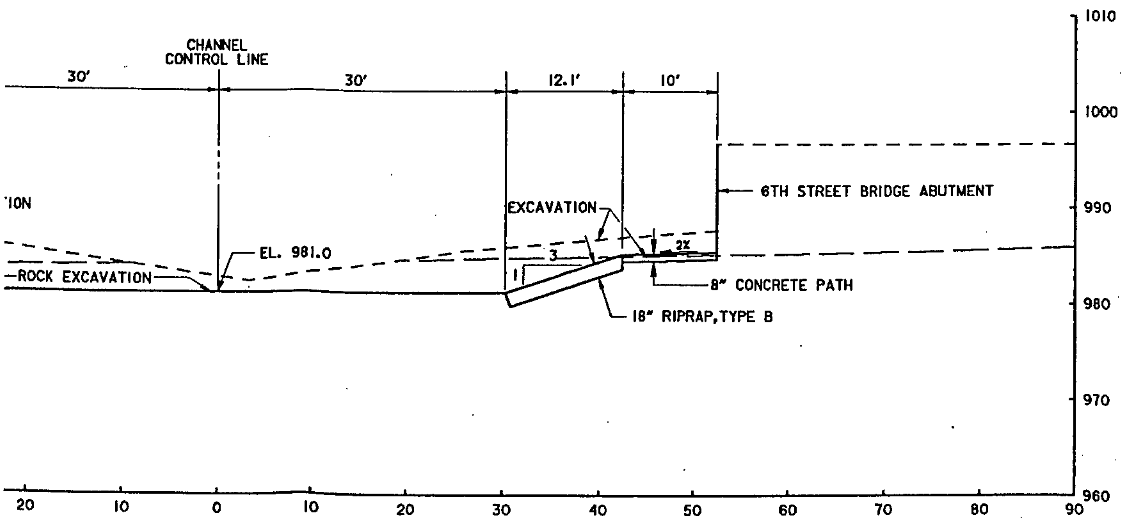


TYPICAL SECTION
STATION 14+90 TO 21+15

13



14



SECTION
STATION 23+75

15

NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED BETWEEN TOPSOIL AND RIPRAP.

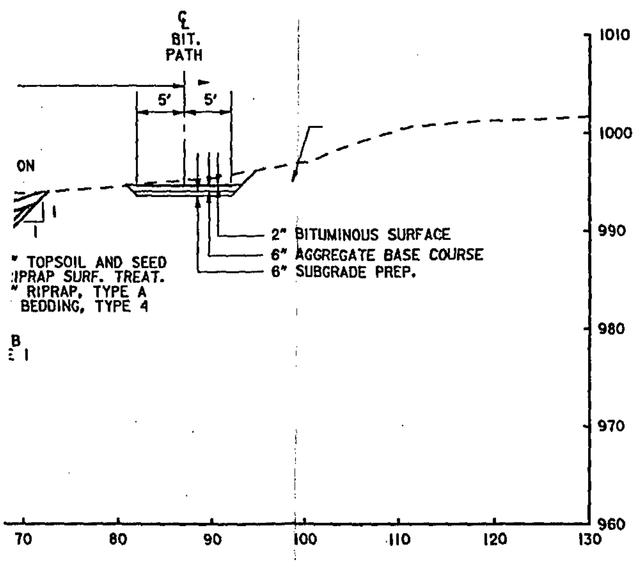
SYMBOL	DESCRIPTION

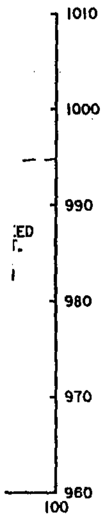
AE APPROVING OFFICIAL:

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/DAE
ED-CH	DESIGNED:	FWC/DAC
ED-CH	CHECKED:	SVD/MSM
	DATE: MAY 92	

DESIGN M
FLOOD CONTROL -
ROCHES
STAGE
CHANNEL
STATION I

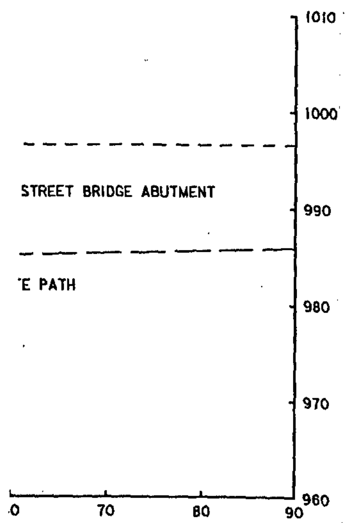
CAD FILE NAME: r4xs05.dgn
SPEC NO:





NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED BETWEEN TOPSOIL AND RIPRAP.



SYMBOL	DESCRIPTION	DATE	APPROVAL

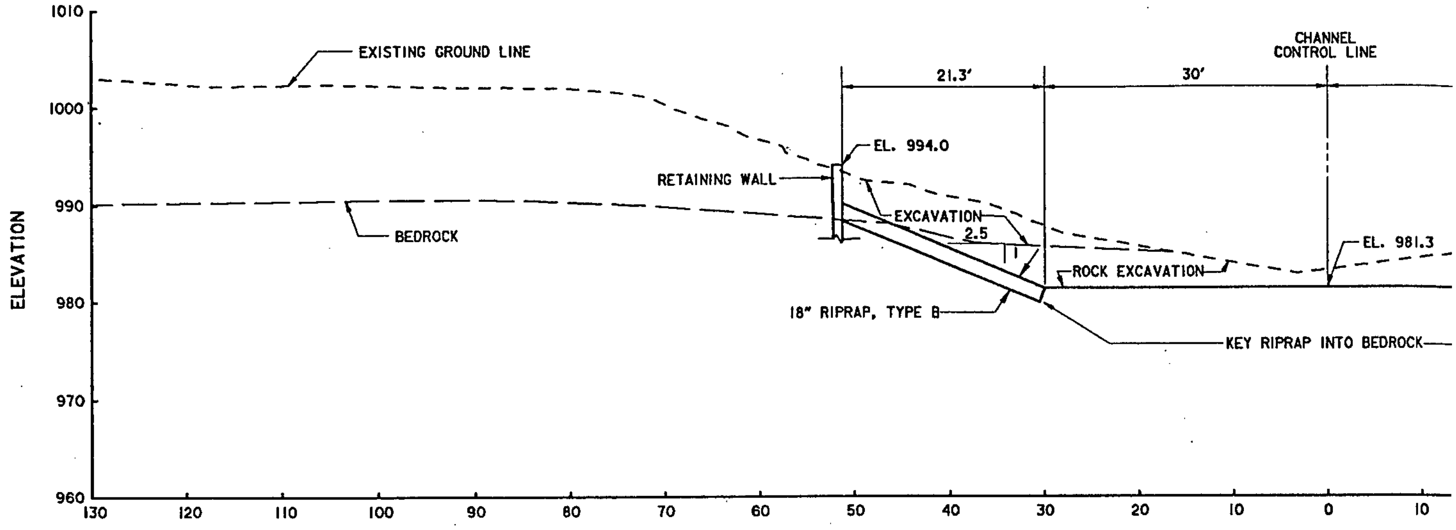
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

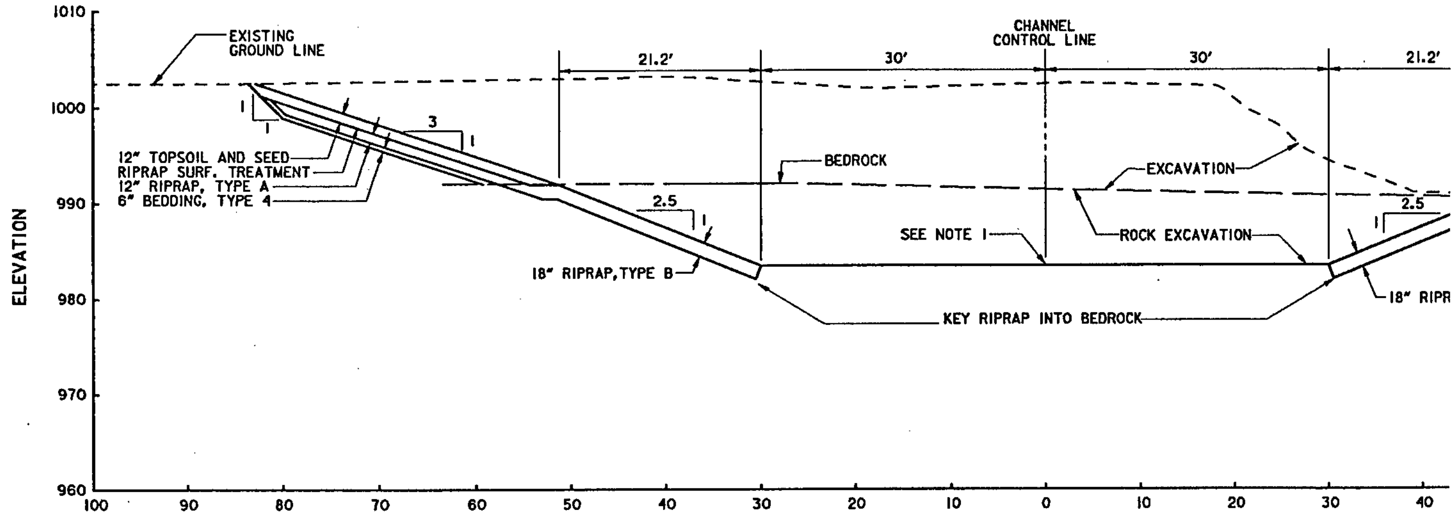
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
CHANNEL SECTIONS 13-15
STATION 14+90 TO 23+75

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/DAE
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM

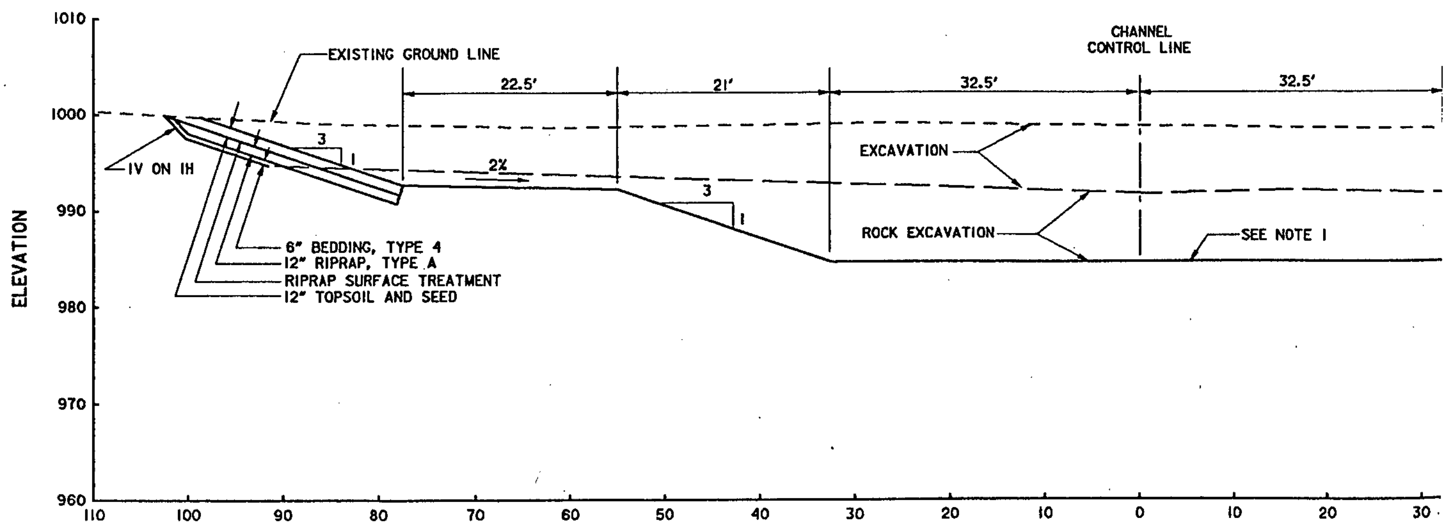
DATE: MAY 92
CAD FILE NAME: r4xs05.dgn
SPEC NO:
DRAWING NUMBER: PLATE 19
SHT 19 OF 53



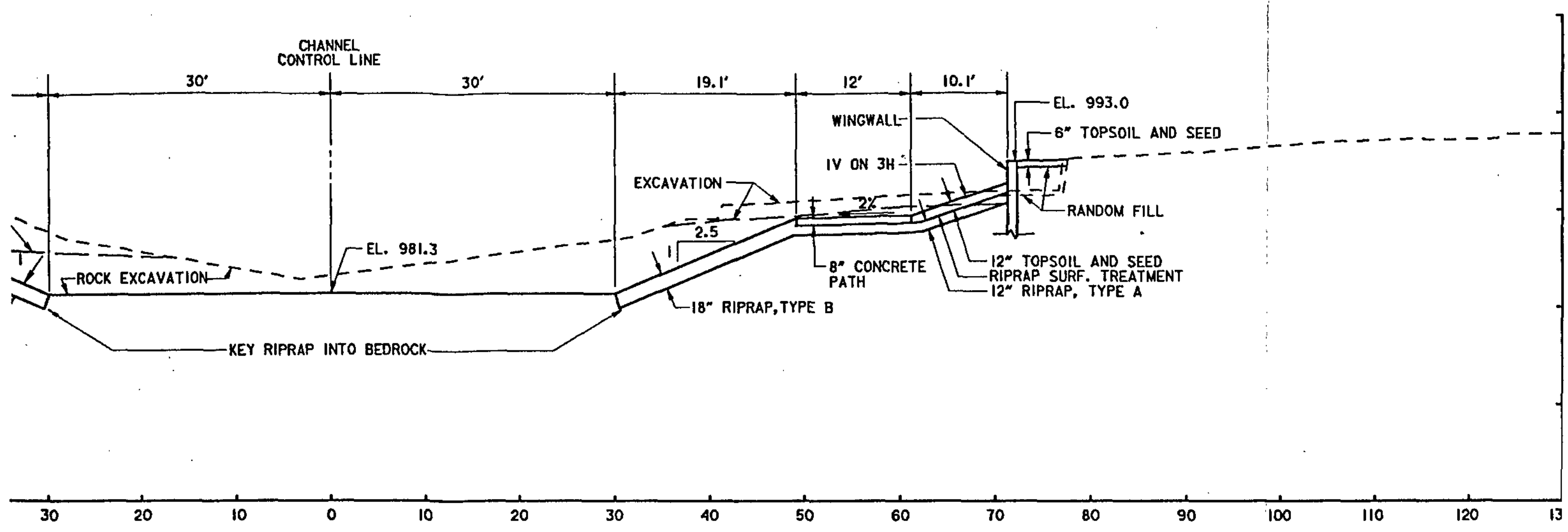
SECTION
STATION 25+00



TYPICAL SECTION 17
STATION 27+50 TO 33+30

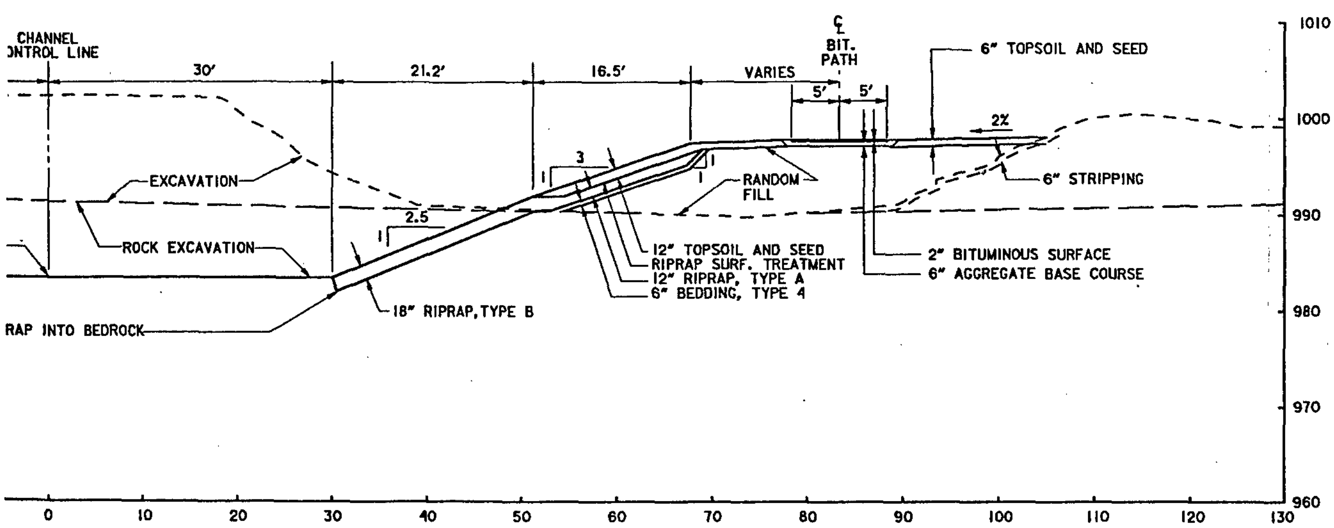


TYPICAL SECTION 18
STATION 37+05 TO 39+00



SECTION
STATION 25+00

16

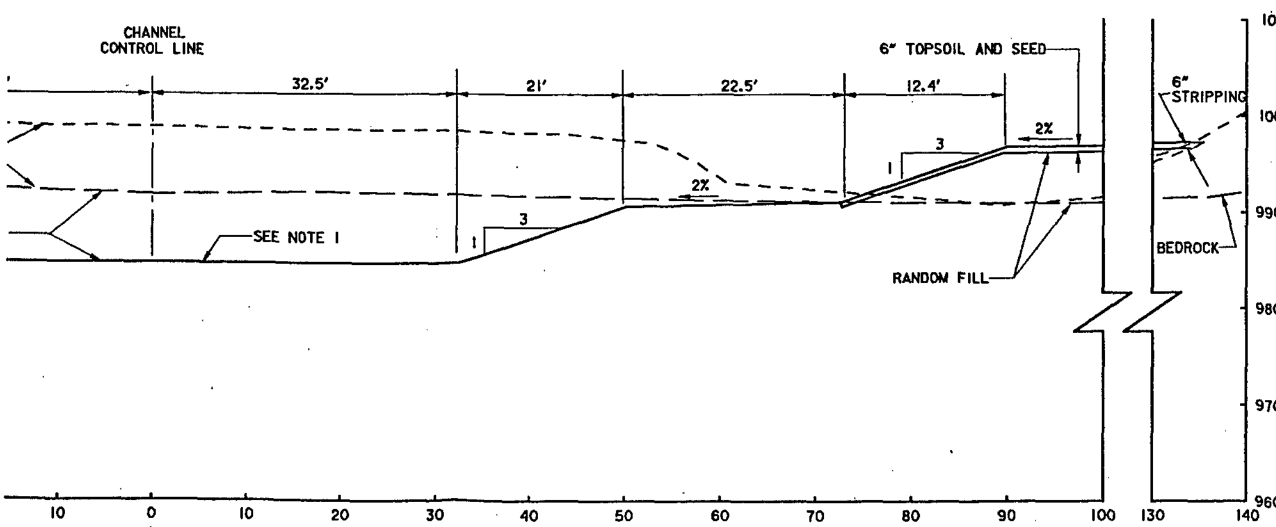


-30

17

NOTES:

1. ELEVATION VARIES - SEE P
2. RIPRAP SURFACE TREATMEN WHERE TOPSOIL IS PLACED AND WHERE CONCRETE PAT



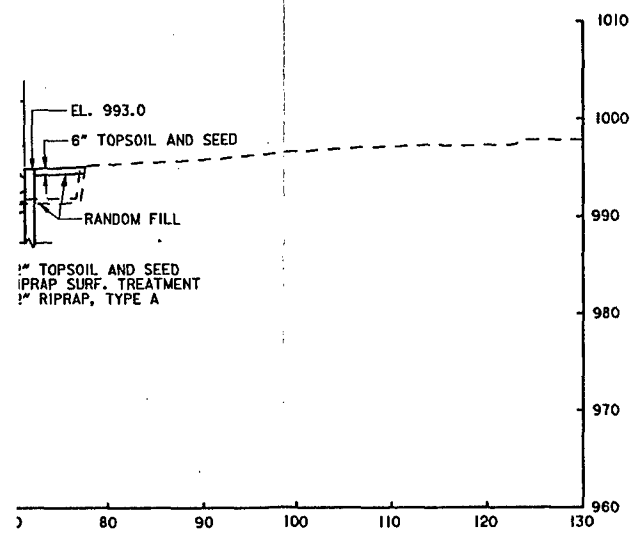
TYPICAL SECTION
STATION 37+05 TO 39+00

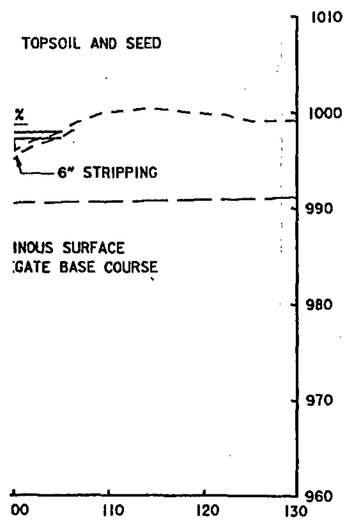
18

SYMBOL	

AE APPROVING OFFICIAL:

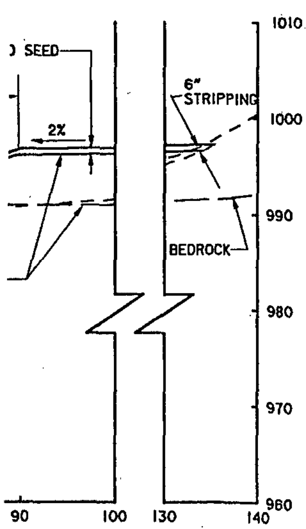
ED-D	DESIGNED: KFB/CAS		
	CHECKED: GVF		
	DRAWN: KFB/dae		
ED-GH	DESIGNED: FWC/DAC		
	CHECKED: SVD/MSM	CAD FILE	
DATE: MAY 92		SPEC NO:	





NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP AND WHERE CONCRETE PATH IS PLACED OVER RIPRAP.



SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

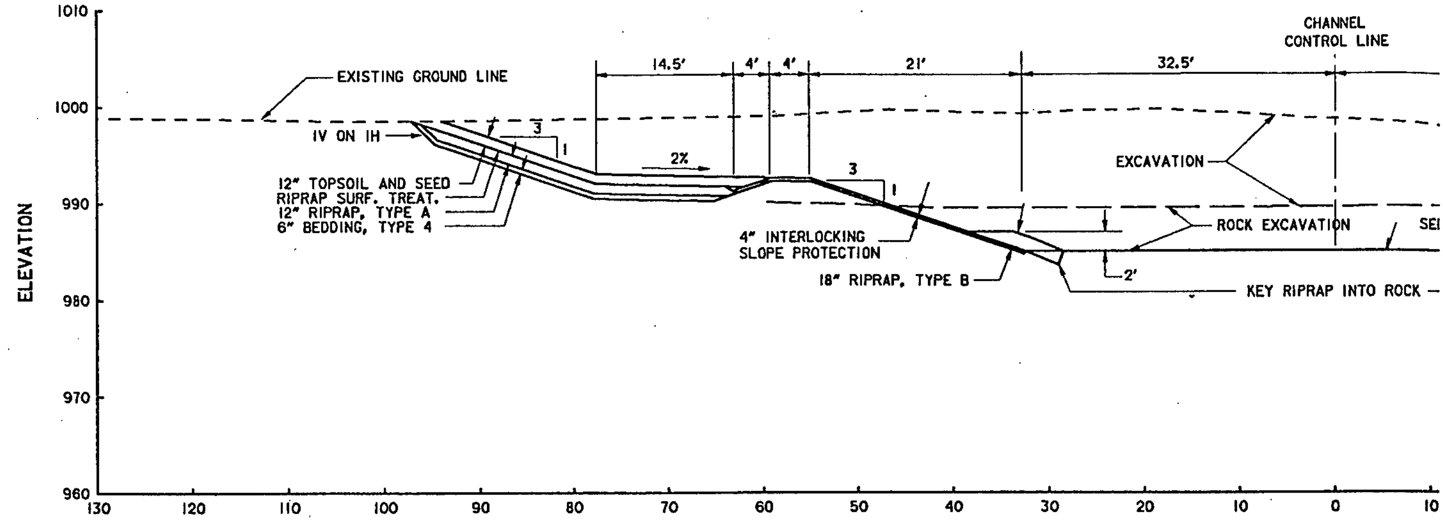
AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

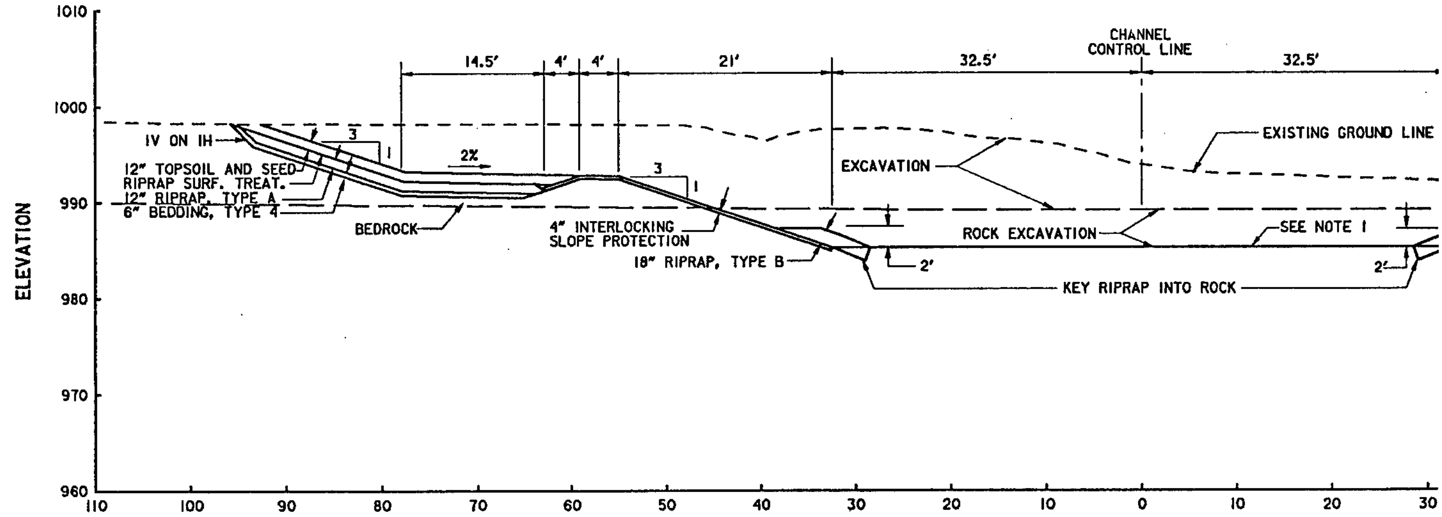
STAGE 4-BEAR CREEK
CHANNEL SECTIONS 16-18
STATION 25+00 TO 39+00

ED-D: DESIGNED: KFB/CAS; CHECKED: GVF; DRAWN: KFB/dae
ED-GH: DESIGNED: FWC/DAC; CHECKED: SVD/MSM
DATE: MAY 92

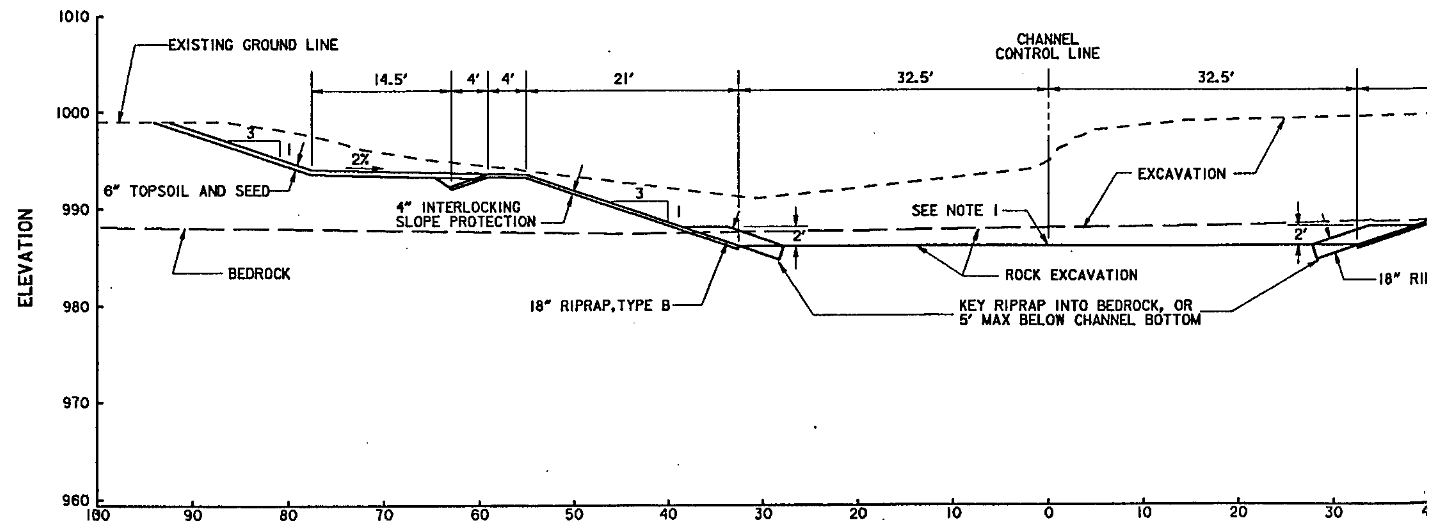
CAD FILE NAME: r4xs06.dgn
SPEC NO:
DRAWING NUMBER: PLATE 20
SHT 20 OF 53



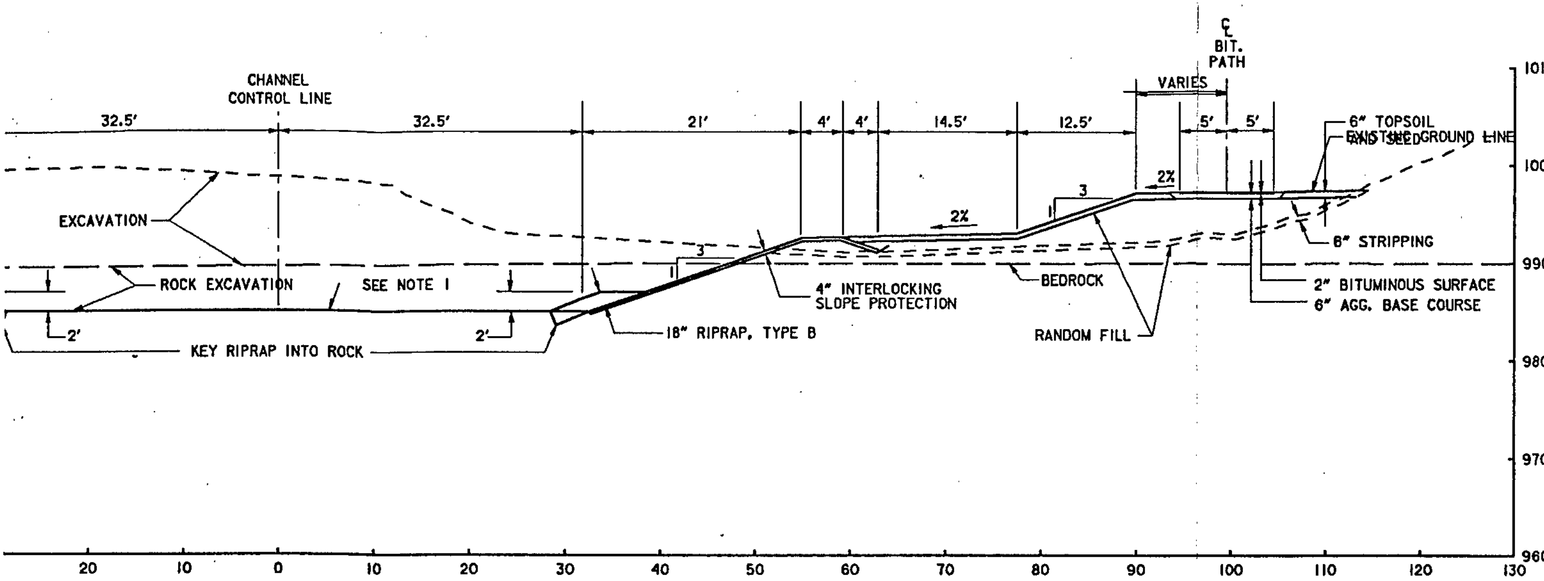
TYPICAL SECTION
STATION 39+00 TO 41+00



TYPICAL SECTION
STATION 41+00 TO 42+00
20

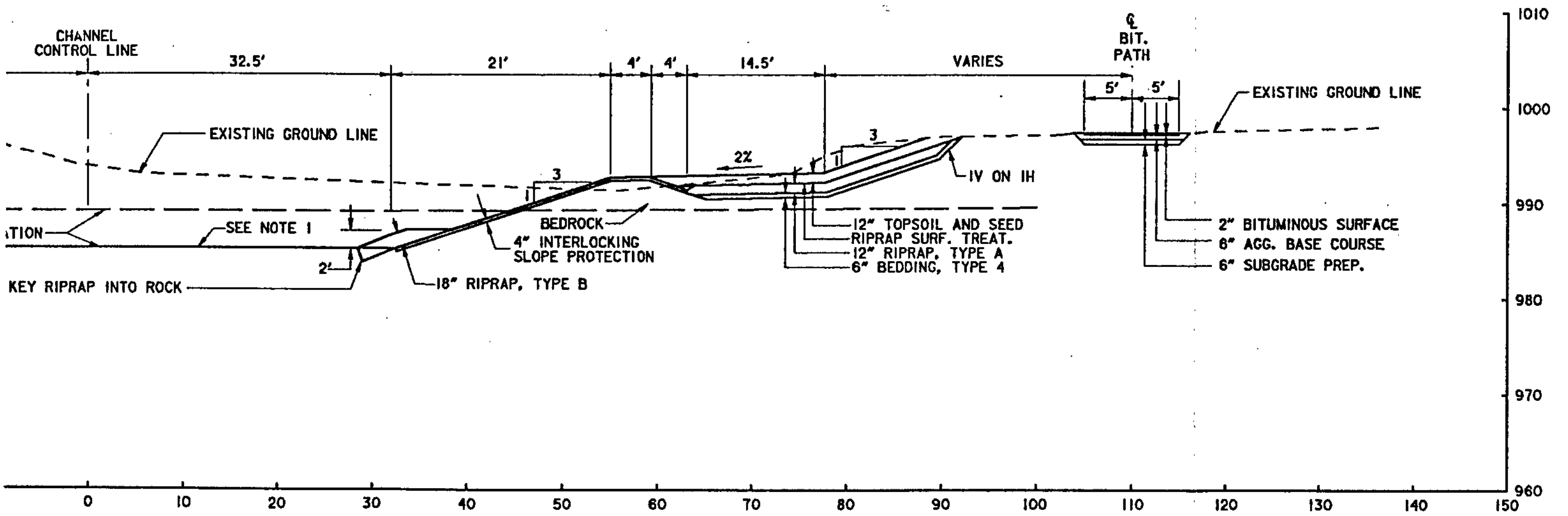


TYPICAL SECTION
STATION 42+00 TO 47+00
21



TYPICAL SECTION
STATION 39+00 TO 41+00

19

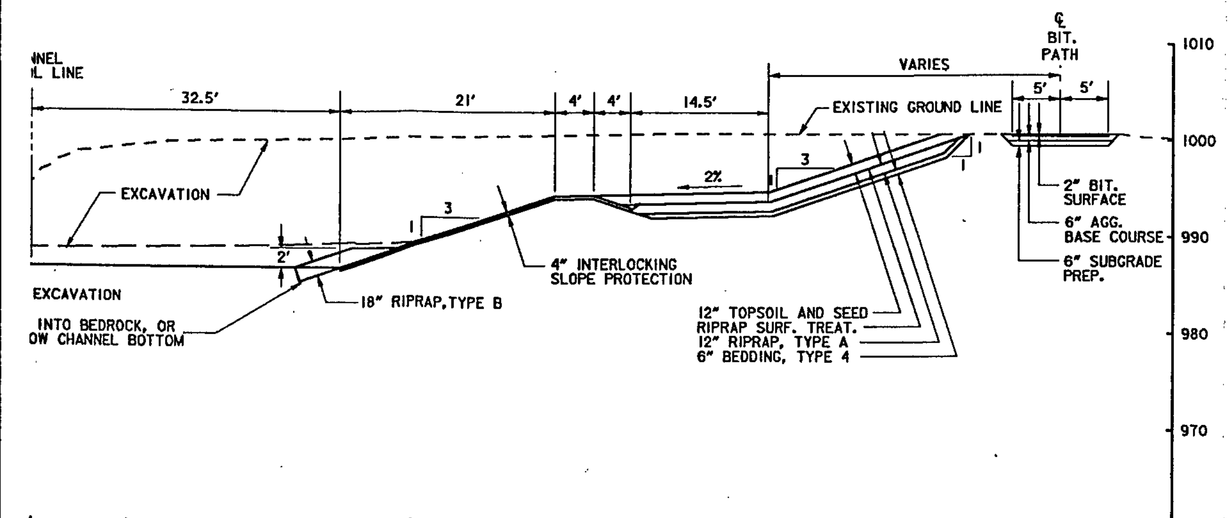


L SECTION
41+00 TO 42+00

20

NOTES:

1. ELEVATION VARIES - SEE PROFIL
2. RIPRAP SURFACE TREATMENT ON
   WHERE TOPSOIL IS PLACED OVEF



47+00

21

SYMBOL	DESCRIPT

AE APPROVING OFFICIAL:

FLOOD CON

ST

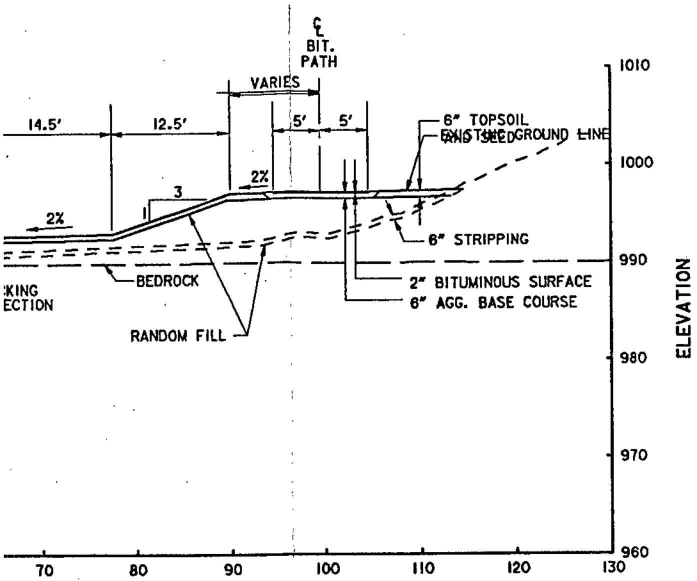
C

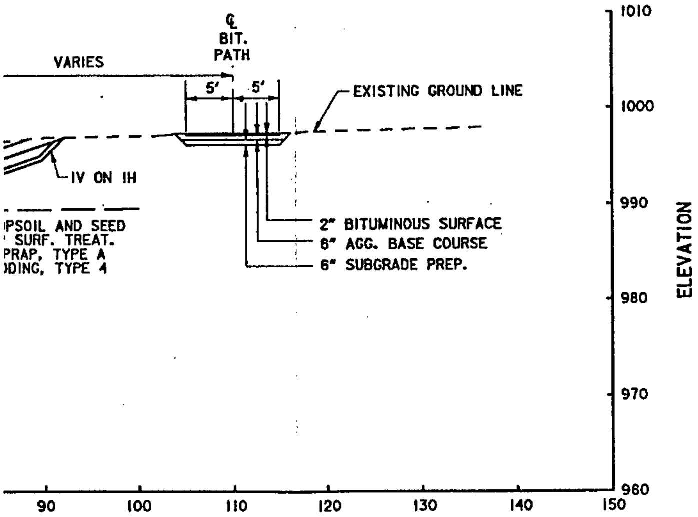
ST

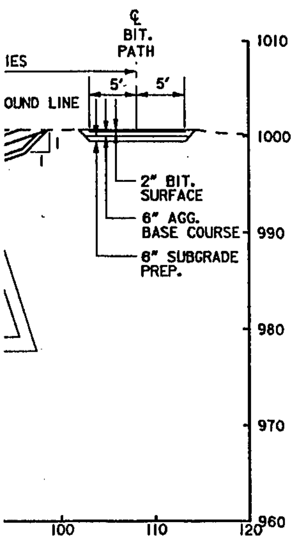
ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM
DATE: MAY 92		

CAD FILE NAME: r4xs07.

SPEC NO:







NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

STAGE 4-BEAR CREEK
CHANNEL SECTIONS 19-21
STATION 39+00 TO 47+00

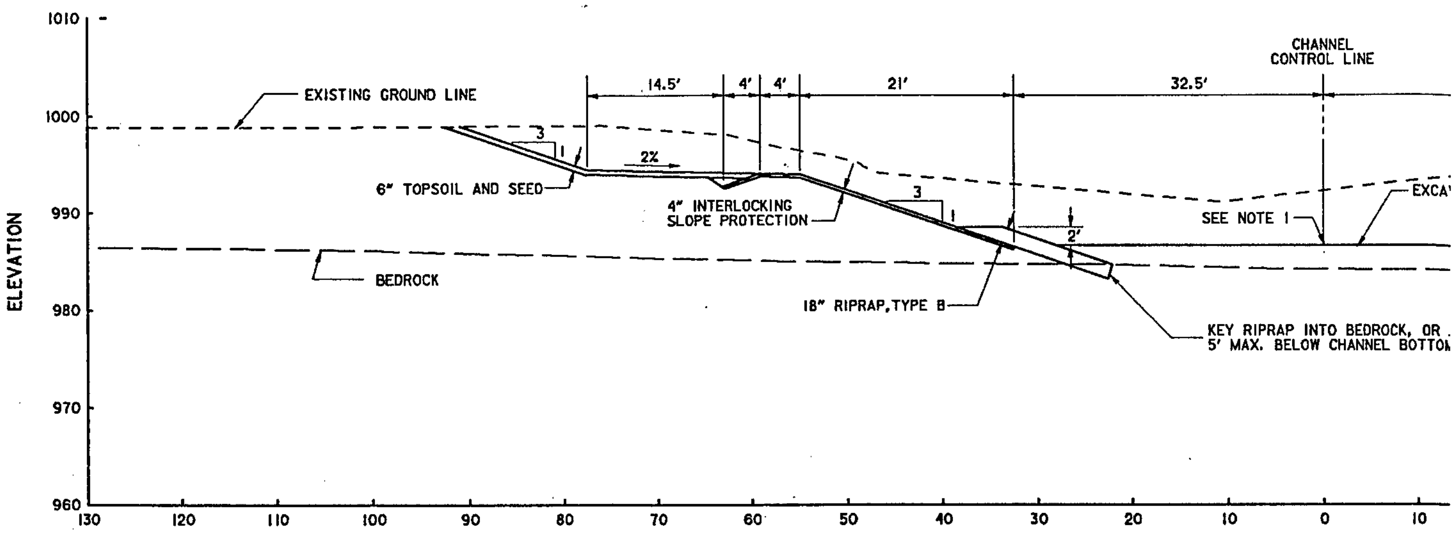
ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM

DATE: MAY 92

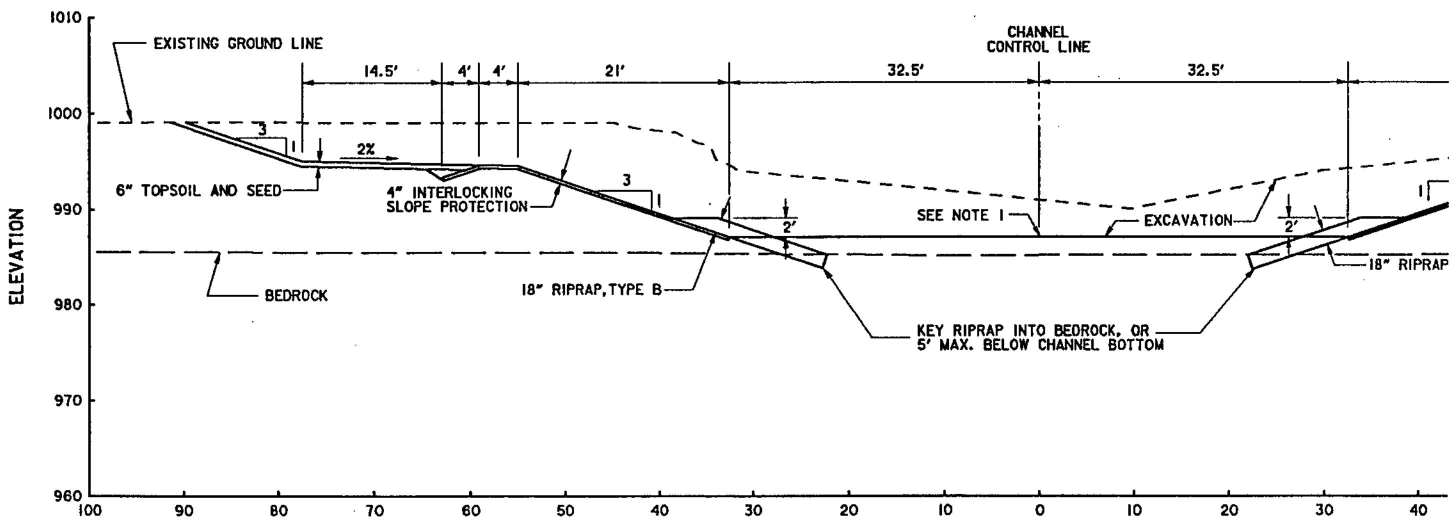
CAD FILE NAME: r4xs07.dgn
SPEC NO:

DRAWING NUMBER: PLATE 21

SHT 21 OF 53

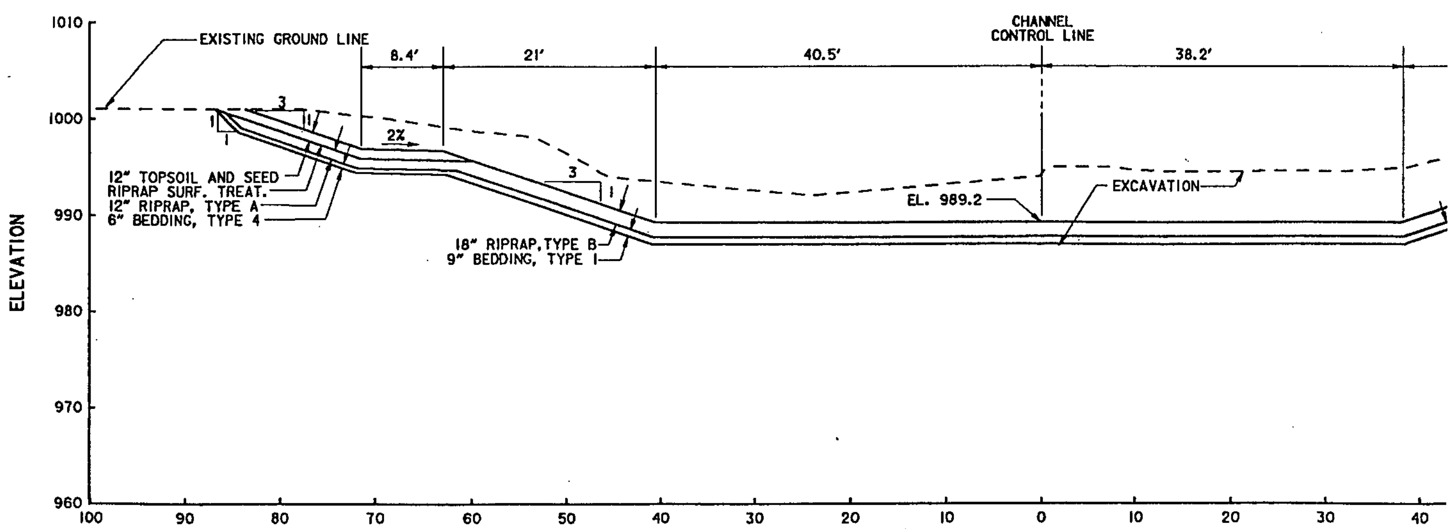


TYPICAL SECTION
STATION 47+00 TO 48+00



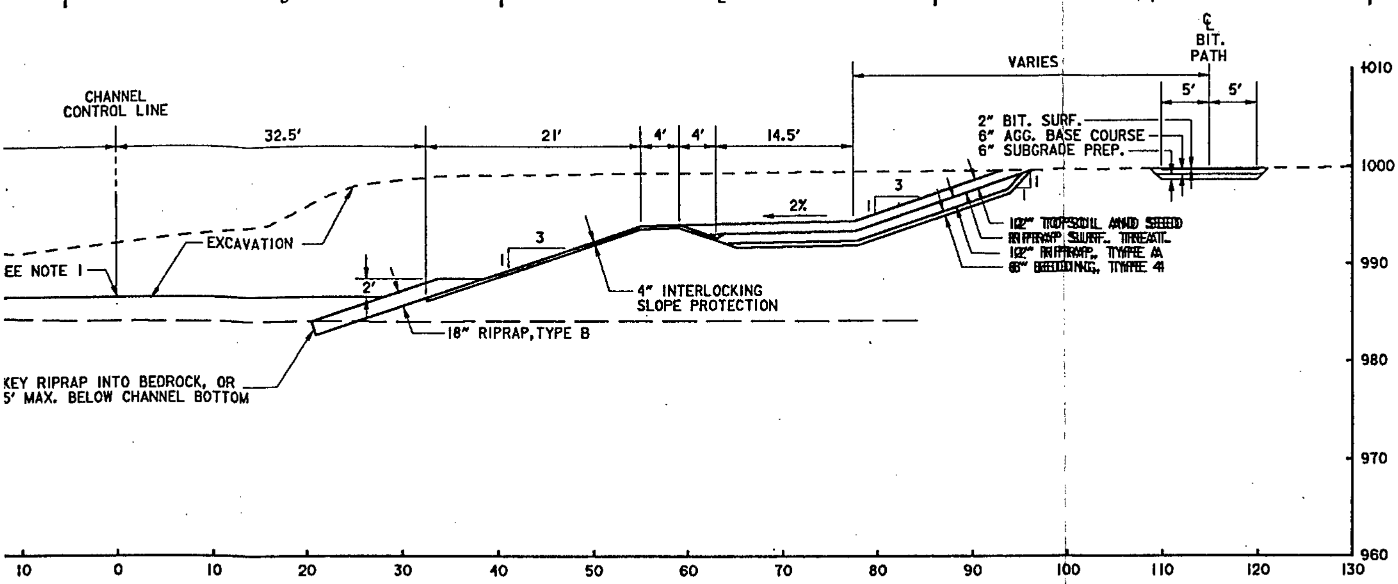
TYPICAL SECTION
STATION 48+00 TO 60+35

23



SECTION
STATION 61+00

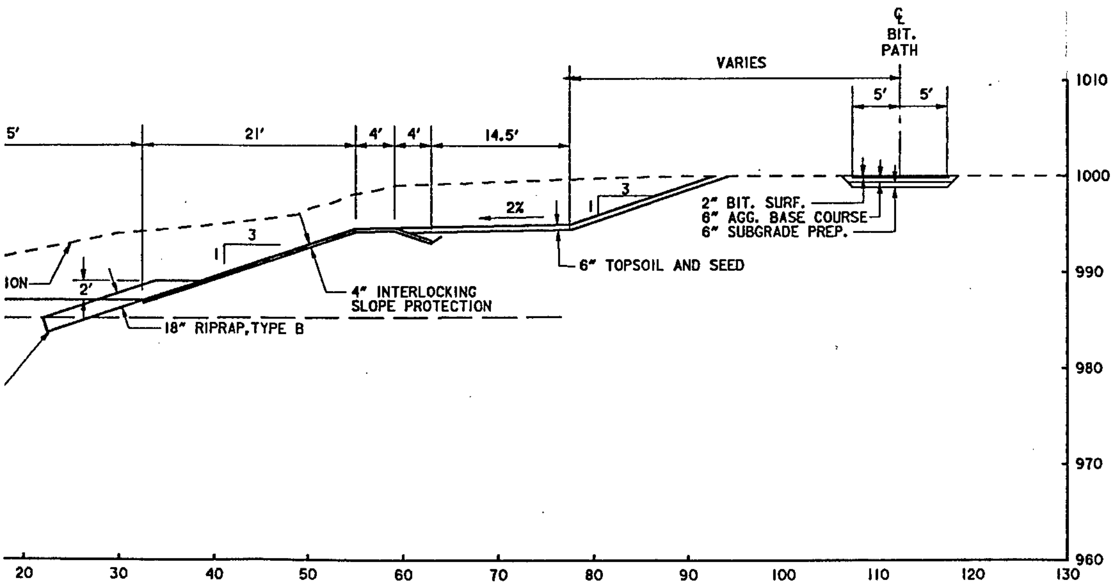
24



PICAL SECTION

ATION 47+00 TO 48+00

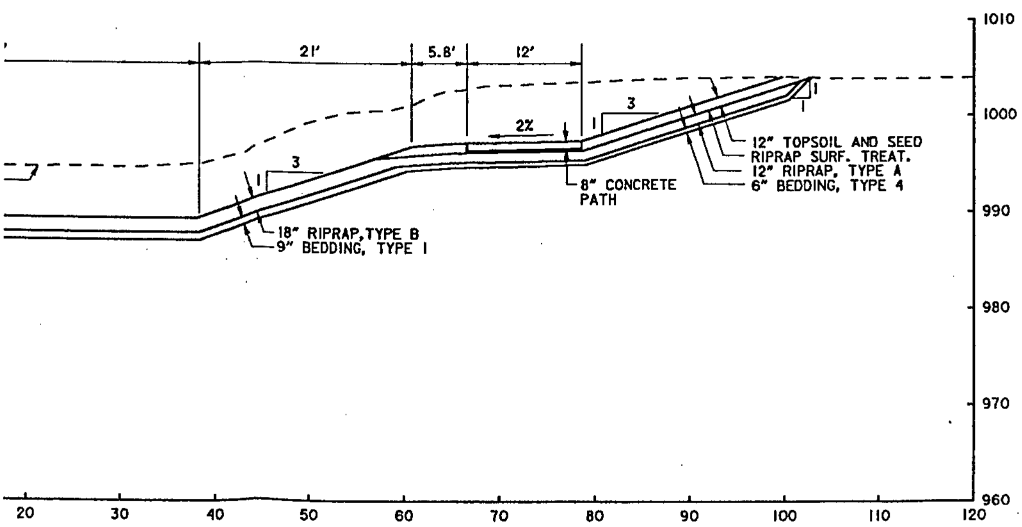
22



]

NOTES:

1. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP AND WHERE CONCRETE PATH IS PLACED OVER RIPRAP



SYMBOL	DESCRIPTION

DEPAR

ST. PAUL DI

S

AE APPROVING OFFICIAL:

DESIGN MEMORAND

FLOOD CONTROL - SOUTH F

ROCHESTER, MIN

STAGE 4-BEA

CHANNEL SECTIO

STATION 47+00

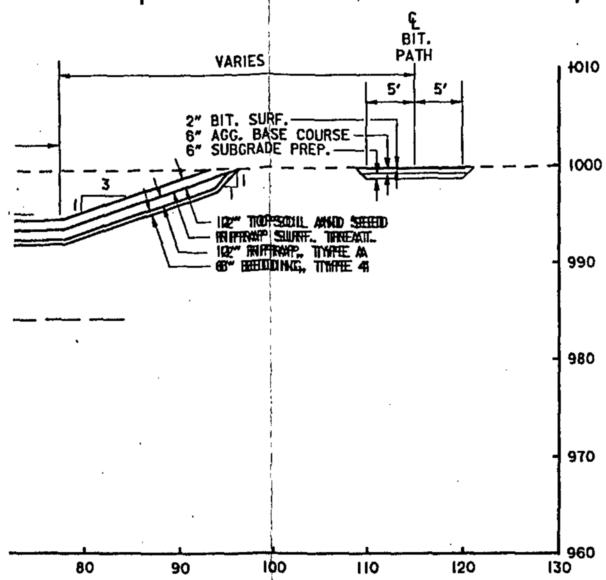
ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/DAE
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM

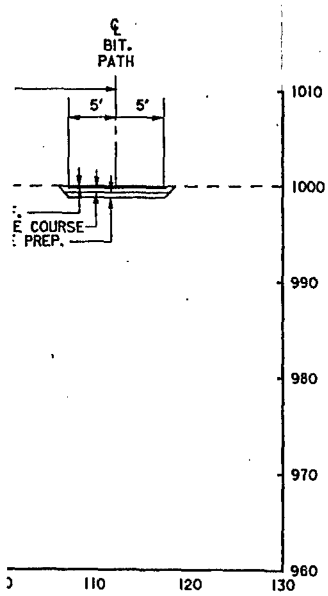
DATE: MAY 92

CAD FILE NAME: r4xs08.dgn

DRAWING

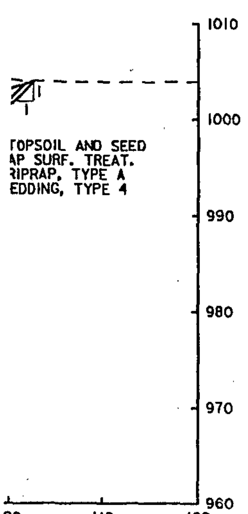
SPEC NO:





NOTES:

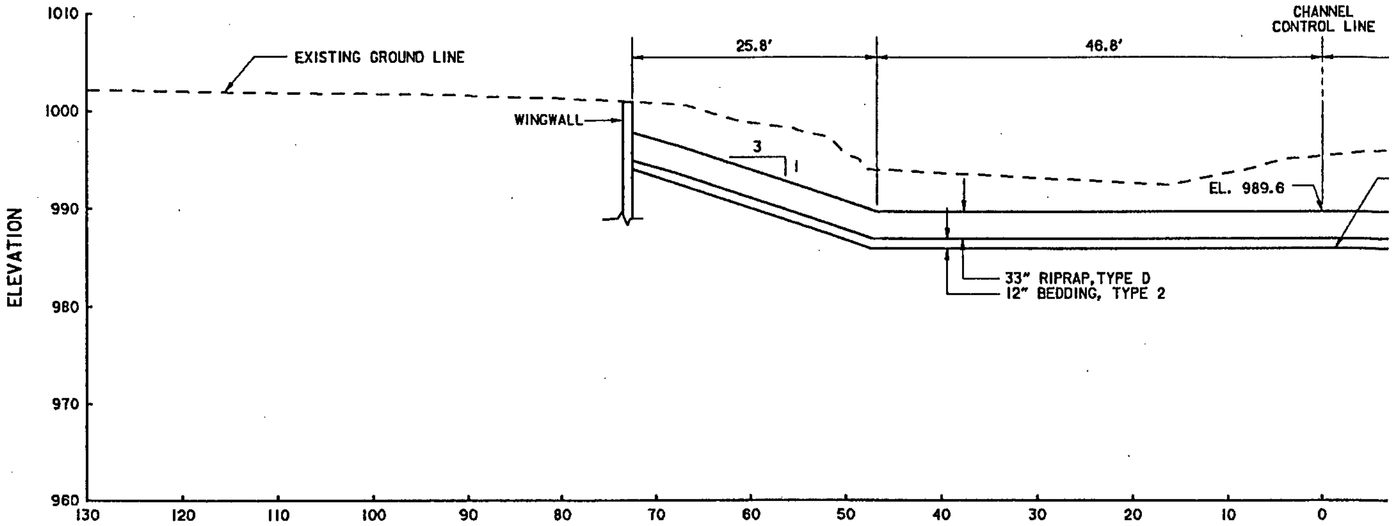
1. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP AND WHERE CONCRETE PATH IS PLACED OVER RIPRAP



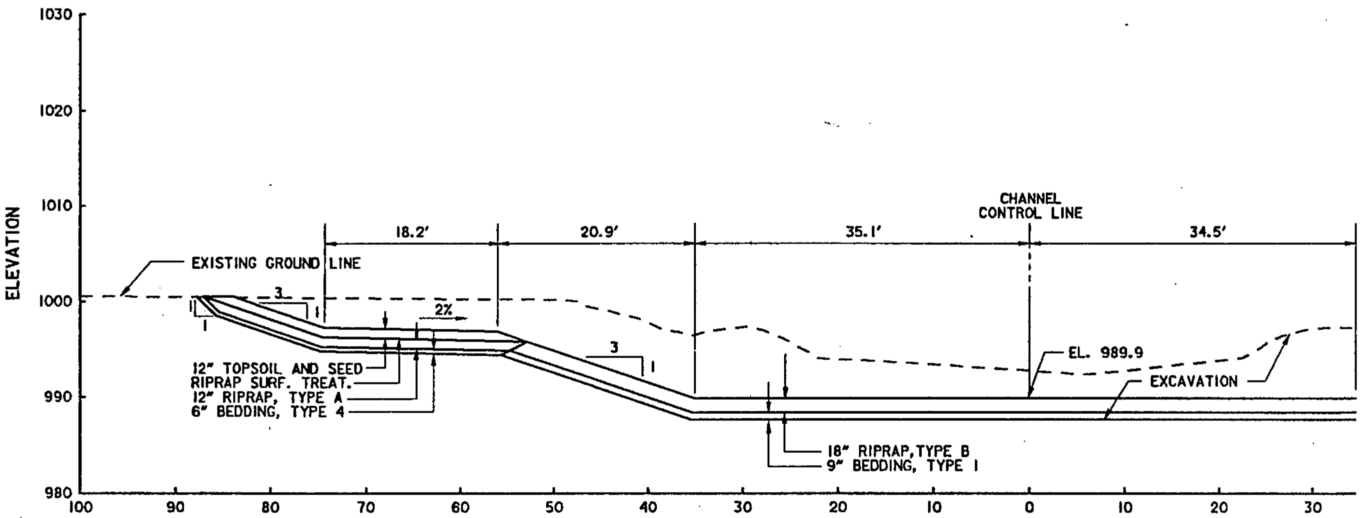
SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:	DESIGN MEMORANDUM NO.6 FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER ROCHESTER, MINNESOTA STAGE 4-BEAR CREEK CHANNEL SECTIONS 22-24 STATION 47+00 TO 61+00	
ED-D DESIGNED: KFB/CAS		
ED-D CHECKED: GVF		
ED-D DRAWN: KFB/DAE		
ED-GH DESIGNED: FWC/DAC		
ED-GH CHECKED: SVD/MSM	CAD FILE NAME: r4xs08.dgn	DRAWING NUMBER: PLATE 22
DATE: MAY 92	SPEC NO:	SHT 22 OF 53

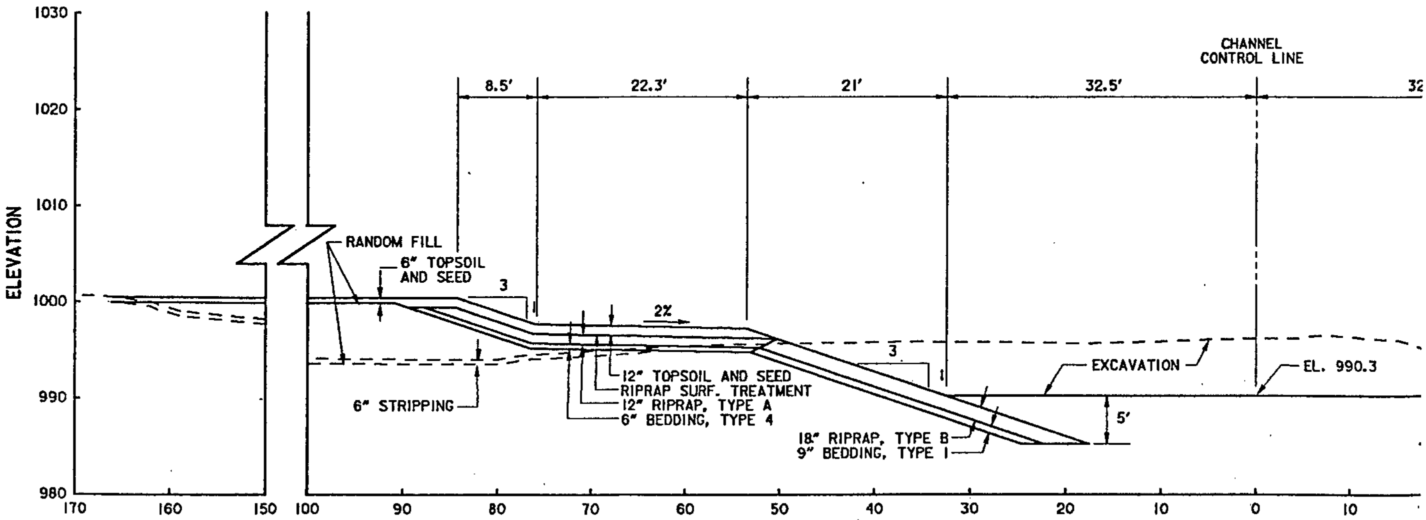


SECTION
STATION 63+00



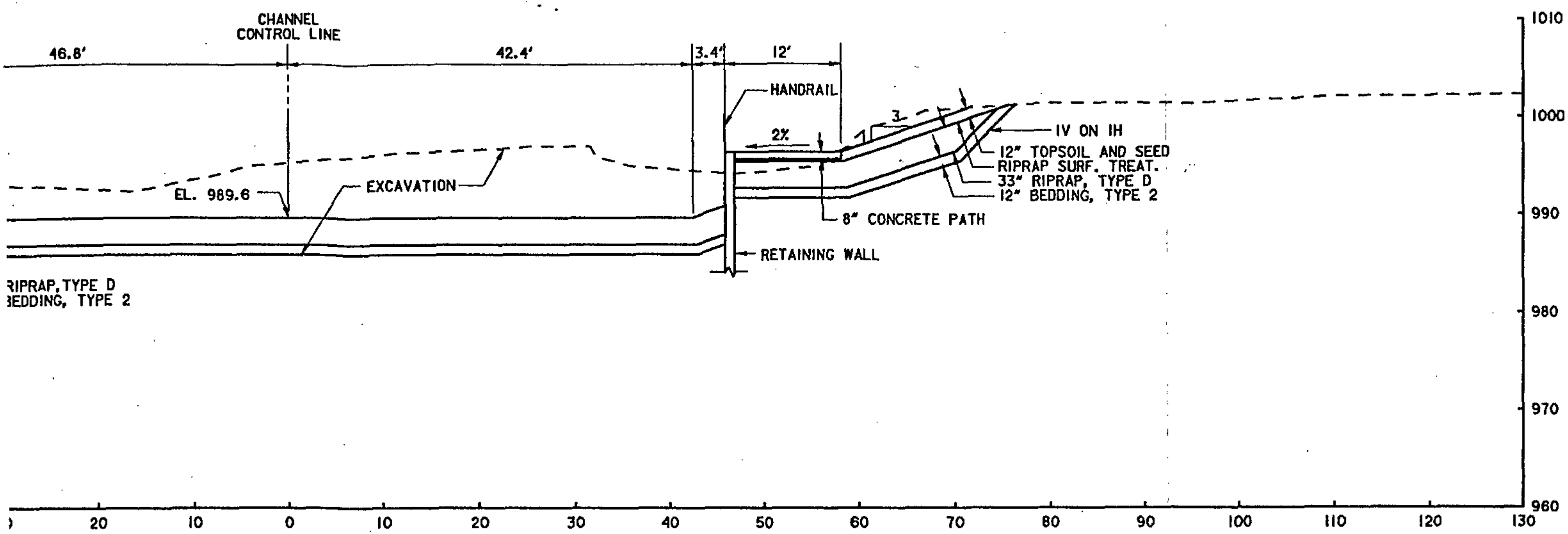
SECTION
STATION 64+00

26

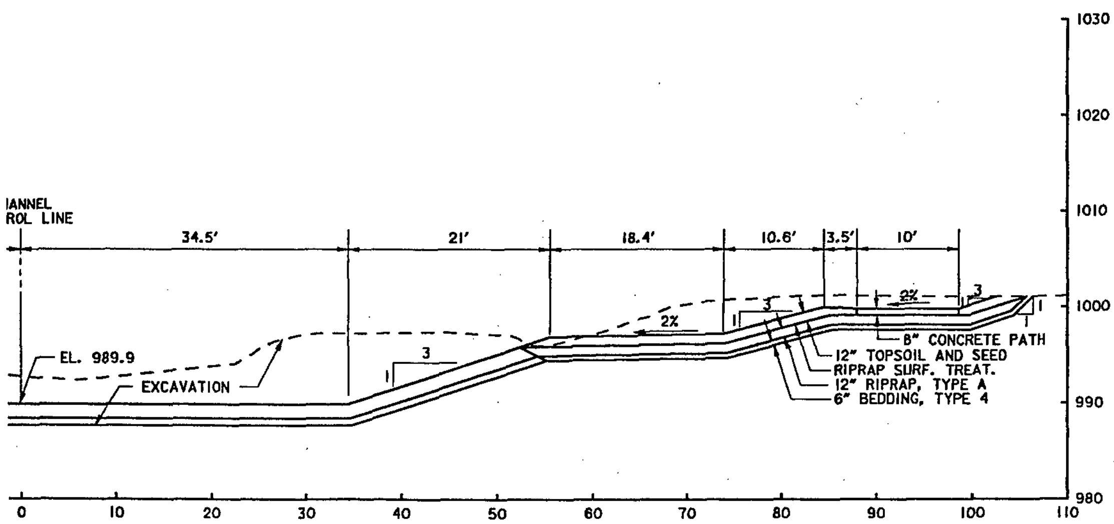


SECTION
STATION 66+00

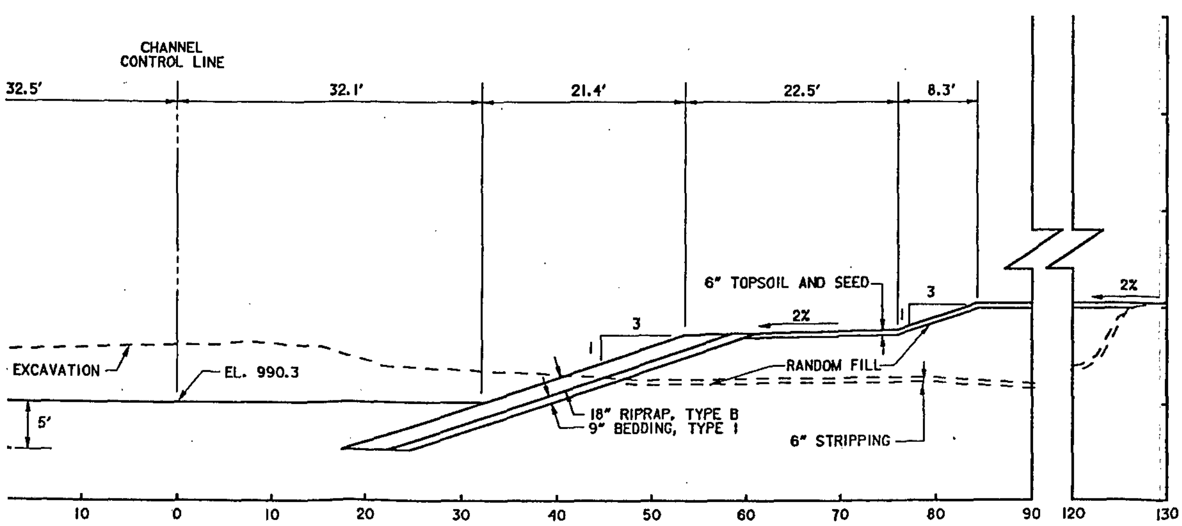
2



SECTION 25
STATION 63+00



26

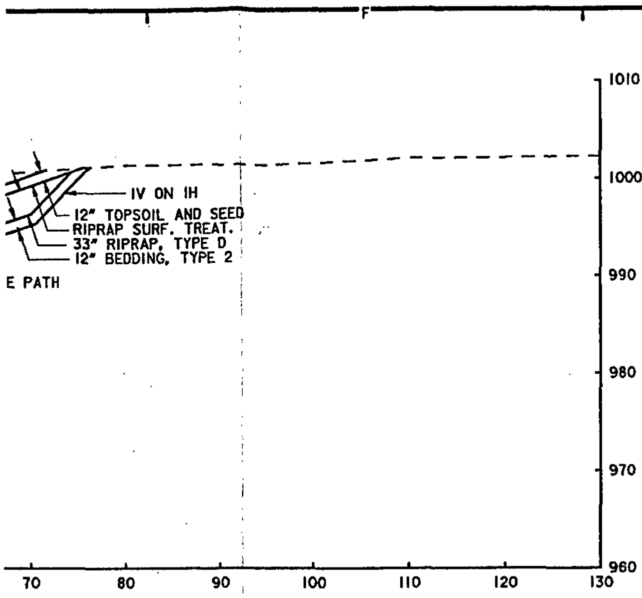


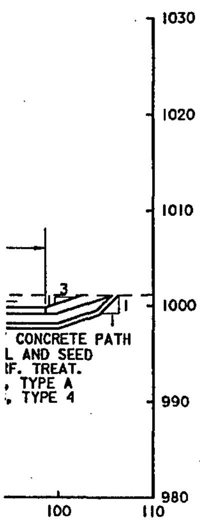
SECTION 27
STATION 66+00

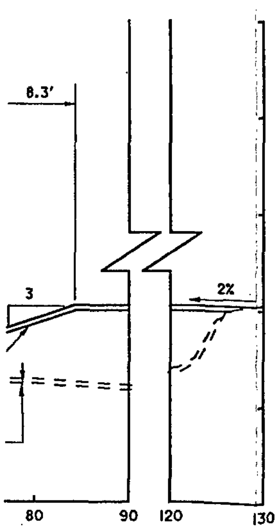
NOTES:

1. RIPRAP SURFACE TREATMENT ONLY RE
TOPSOIL IS PLACED OVER RIPRAP, AN
PATH IS PLACED OVER RIPRAP

SYMBOL	DESCRIPT
AE APPROVING OFFICIAL:	C FLOOD CONT R ST CH ST/
ED-D DESIGNED: KFB/CAS	
CHECKED: GVF	
DRAWN: KFB/DAE	
ED-GH DESIGNED: FWC/DAC	
CHECKED: SVD/MSM	CAD FILE NAME: r4xs09.
DATE: MAY 92	SPEC NO:







NOTES:

1. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP, AND WHERE PATH IS PLACED OVER RIPRAP

SYMBOL	DESCRIPTION	DATE	APPROVAL

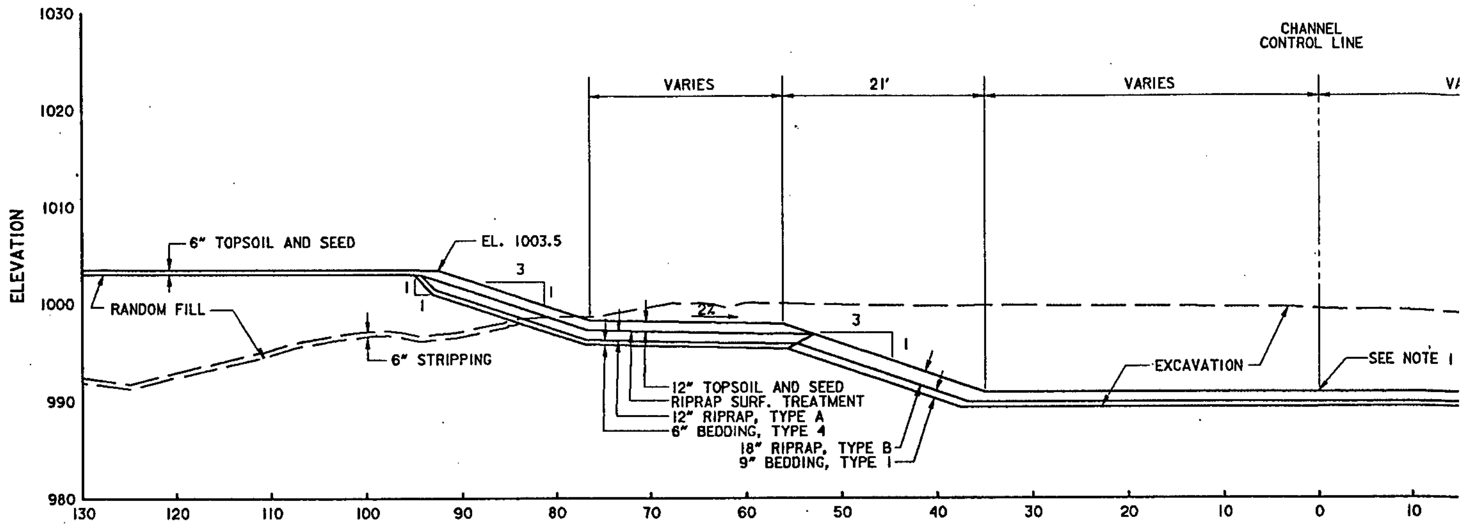
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

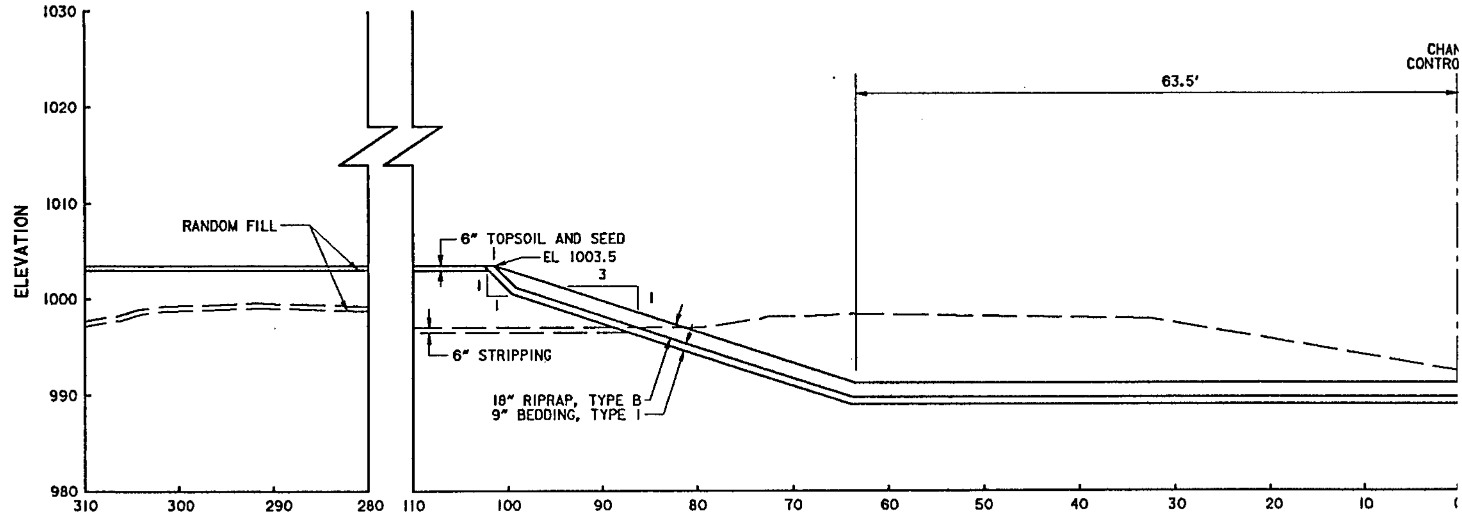
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
CHANNEL SECTIONS 25-27
STATION 63+00 TO 66+00

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/DAE
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM

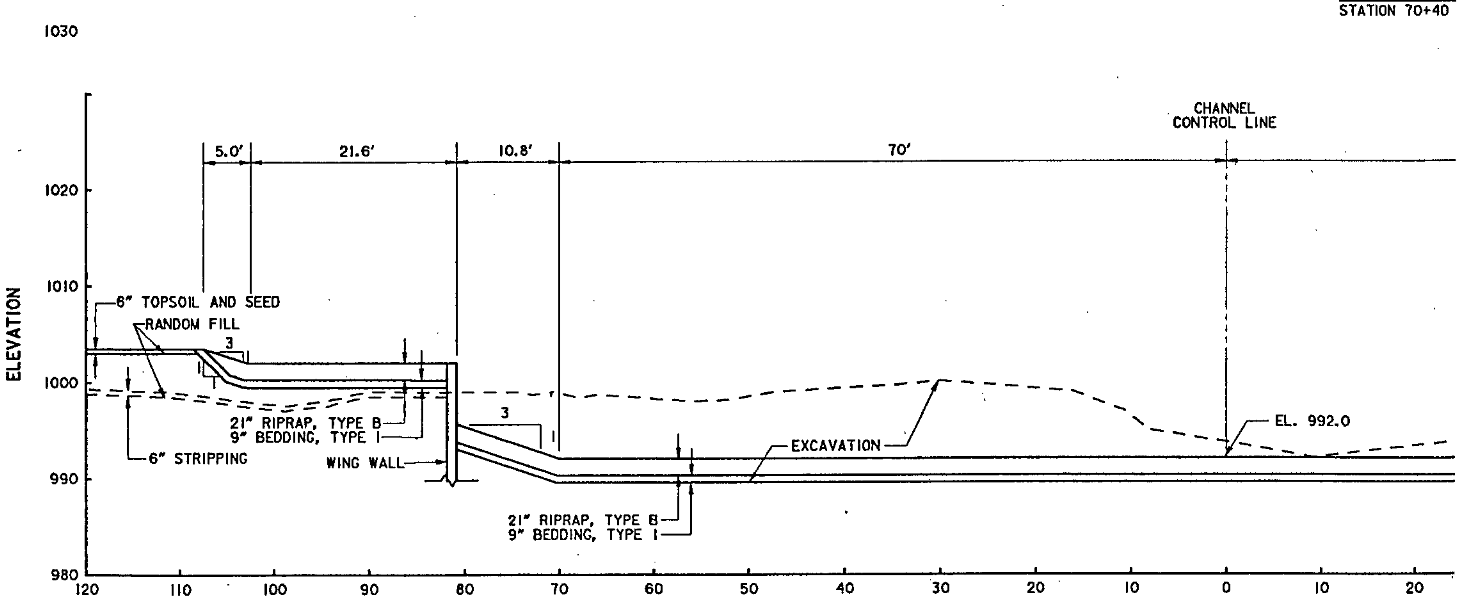
DATE: MAY 92
CAD FILE NAME: r4xs09.dgn
SPEC NO:
DRAWING NUMBER: PLATE 23
SHT 23 OF 53



TYPICAL SECTION
STATION 68+83 TO 70+40

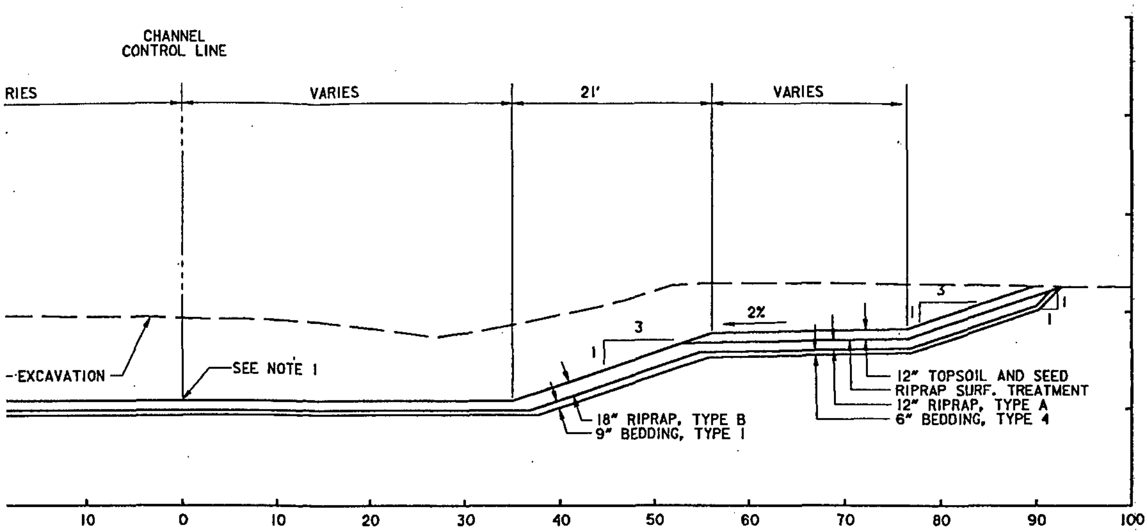


TYPICAL SECTI
STATION 70+40



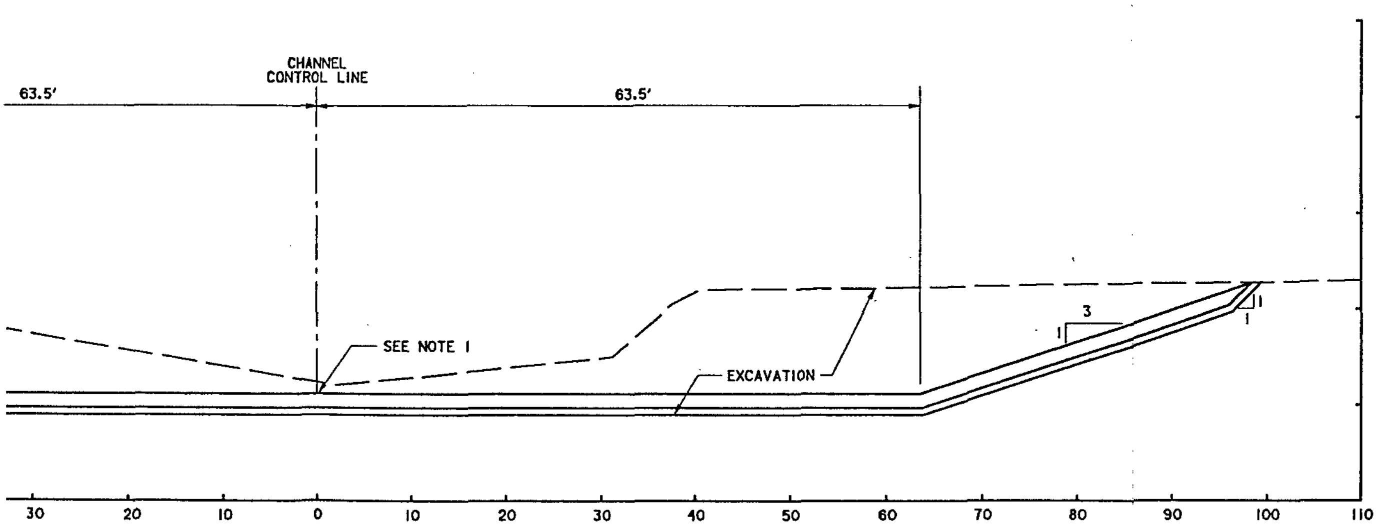
SECTION
STATION 71+10

30



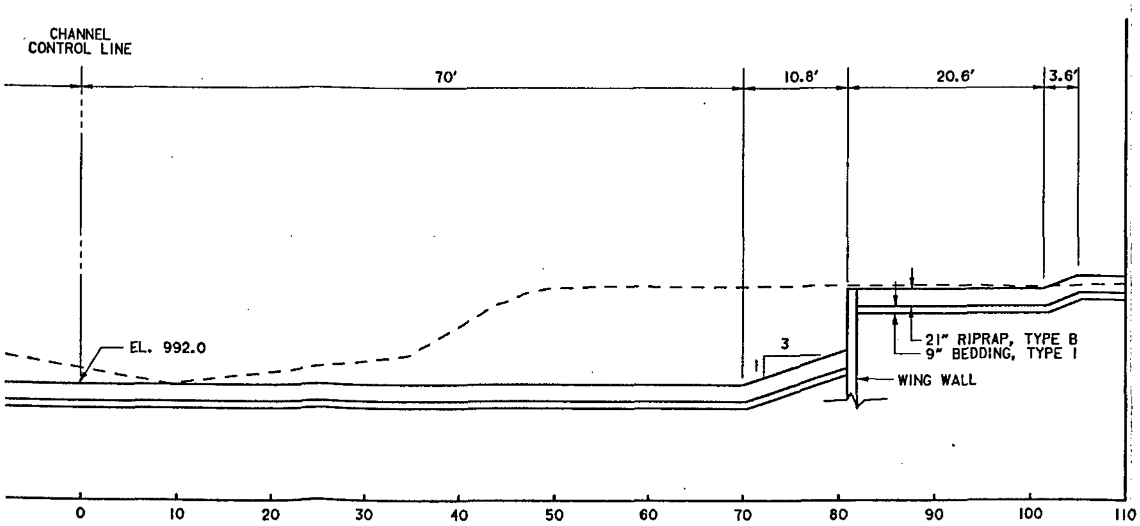
TYPICAL SECTION
STATION 68+83 TO 70+40

28



TYPICAL SECTION
STATION 70+40 TO 71+08

29



ION
ON 71+10

30

NOTES:

1. ELEVATION VARIES - SEE
2. RIPRAP SURFACE TREATM
   REQUIRED WHERE TOPSOI

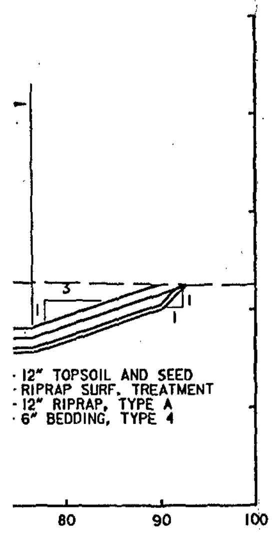
SYMBOL	DESCRIPTION

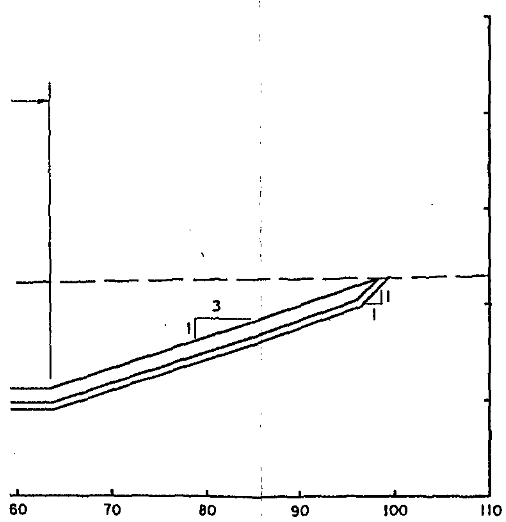
AE APPROVING OFFICIAL:

DESIGN
FLOOD CONTROL -
ROCHES
STAGE
CHANNEL
STATION

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM
DATE: MAY 92		

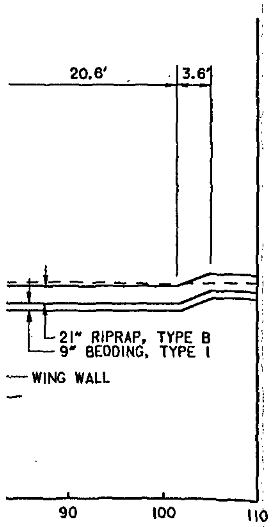
CAD FILE NAME: r4xs10.dgn
SPEC NO:





NOTES:

1. ELEVATION VARIES - SEE PROFILE.
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP.



SYMBOL	DESCRIPTION	DATE	APPROVAL

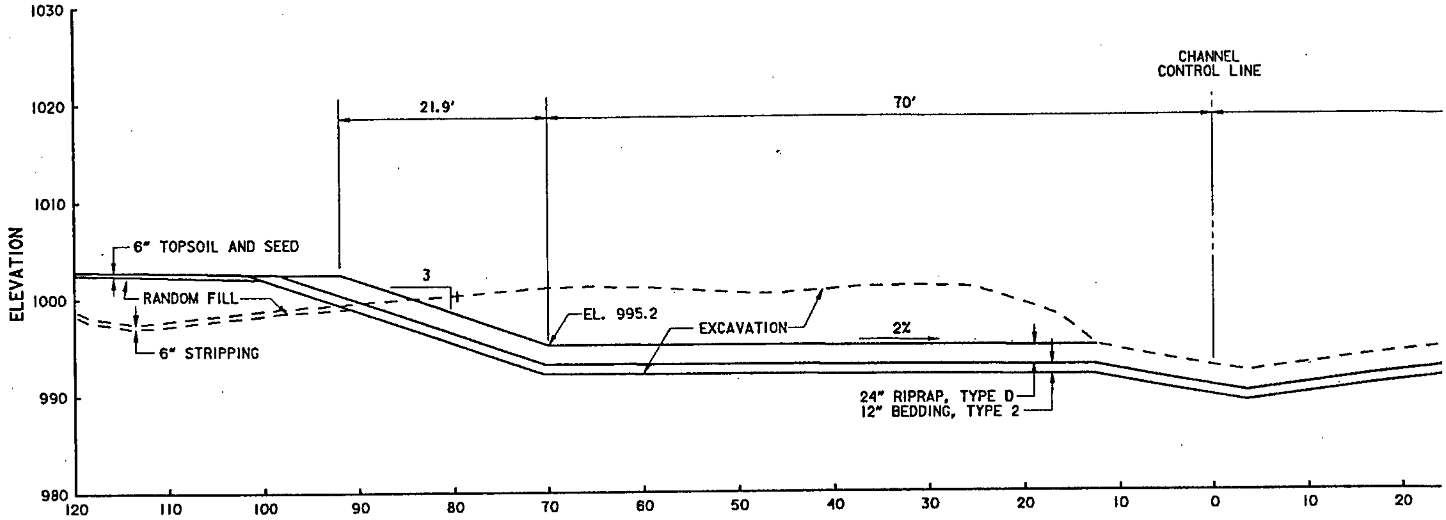
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
CHANNEL SECTIONS 28-30
STATION 68+83 TO 71+10

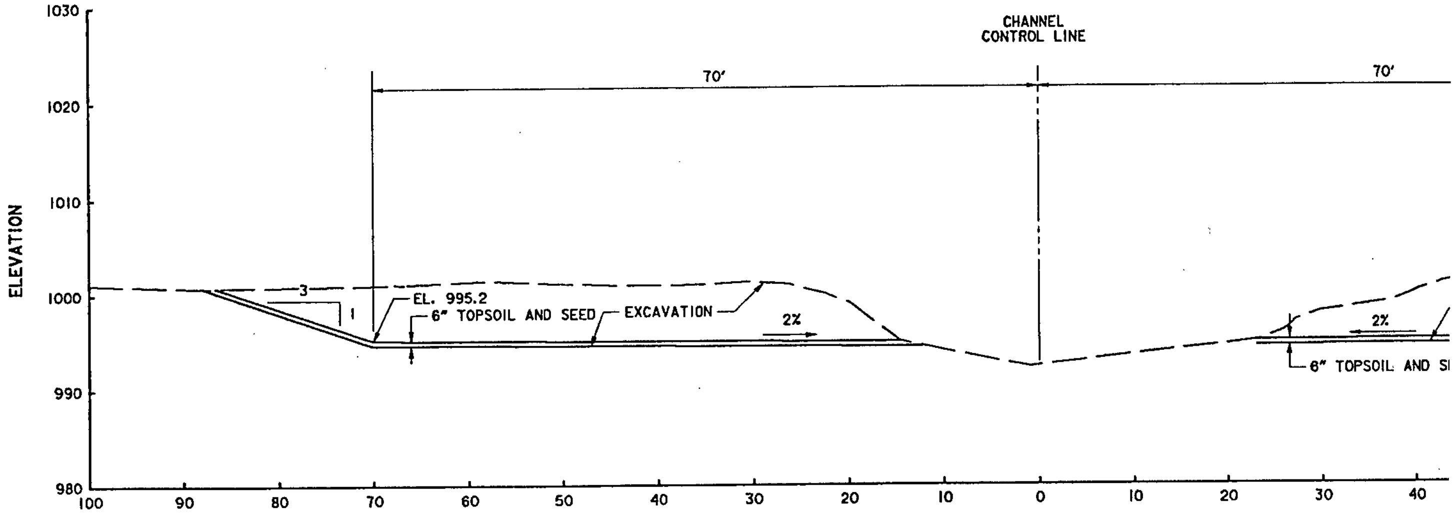
ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
	CHECKED:	SVD/MSM
DATE: MAY 92		

CAD FILE NAME: r4xs10.dgn
SPEC NO:
DRAWING NUMBER: PLATE 24
SHT 24 OF 53



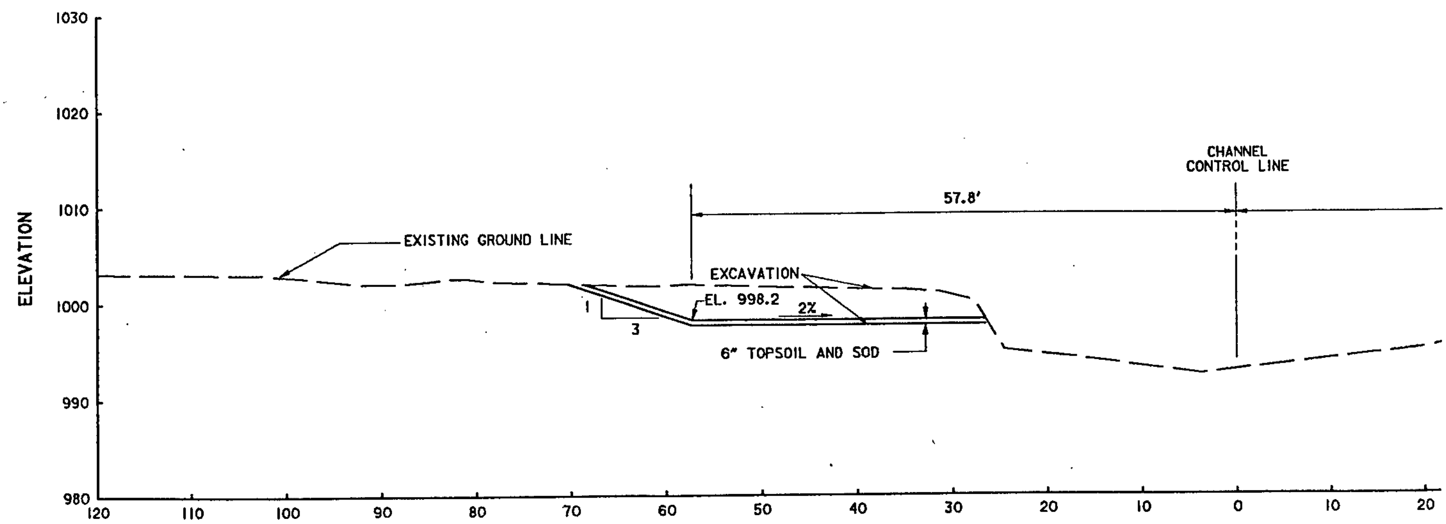
TYPICAL SECTION
STATION 71+80 TO 71+91

31



TYPICAL SECTION
STATION 71+91 TO 73+15

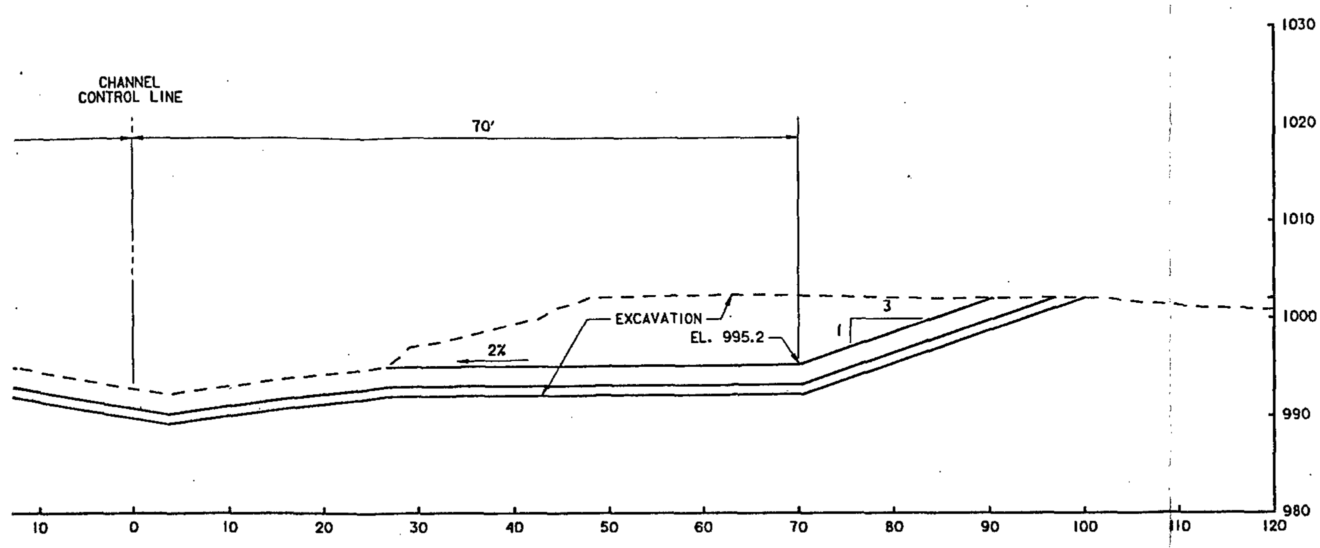
32



TYPICAL SECTION
STATION 73+50

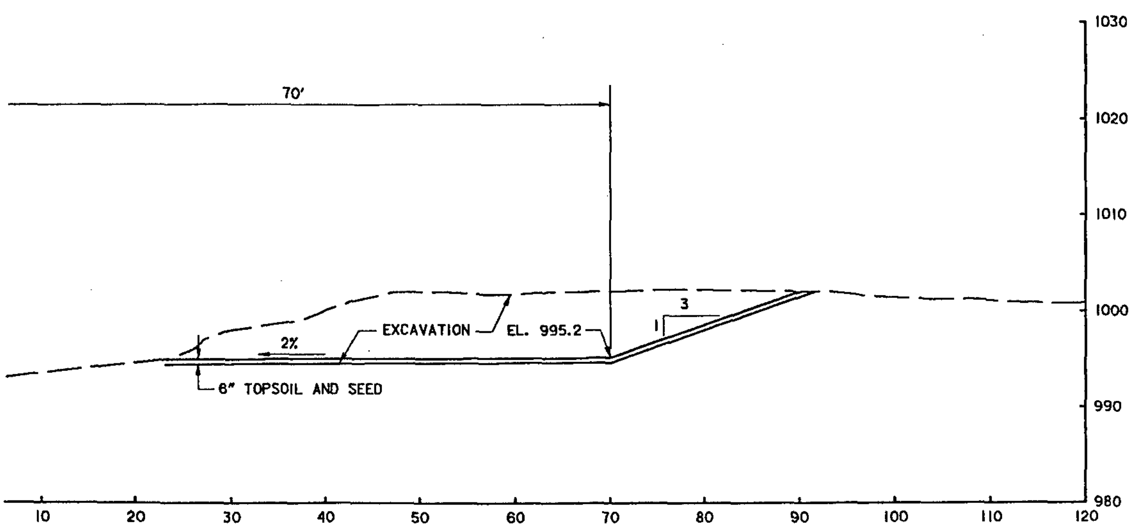
33

D E F

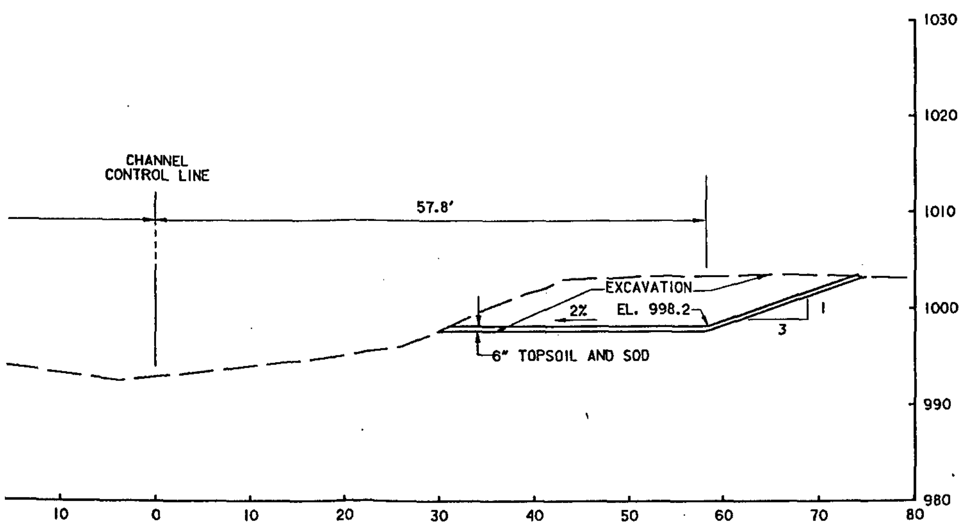


YPICAL SECTION
TATION 71+80 TO 71+91

31



32



33

SYMBOL	DESCRIPTI

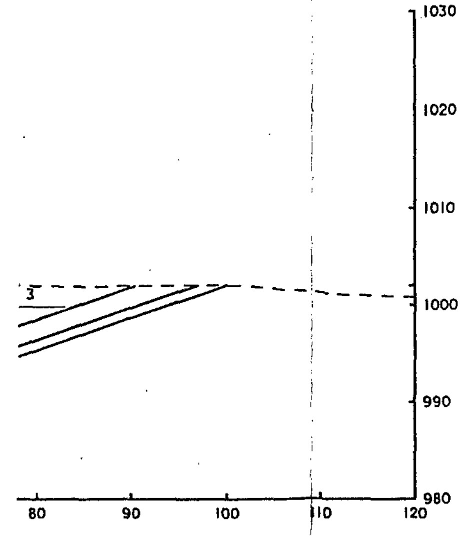
AE APPROVING OFFICIAL:

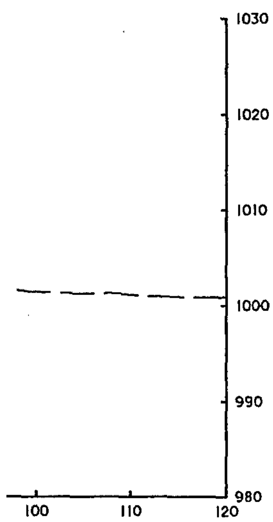
FLOOD CONT
R
ST
CH
ST

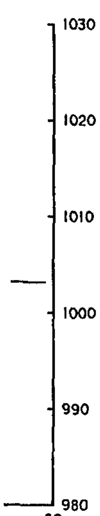
ED-D	DESIGNED: KFB/CAS
	CHECKED: GVF
	DRAWN: KFB/DAE
ED-GH	DESIGNED: FWC/DAC
	CHECKED: SVD/MSM

CAD FILE NAME: r4xs313
DATE: MAY 92
SPEC NO:

D F







SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

ED-D
DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: KFB/DAE

ED-GH
DESIGNED: FWC/DAC
CHECKED: SVD/MSM

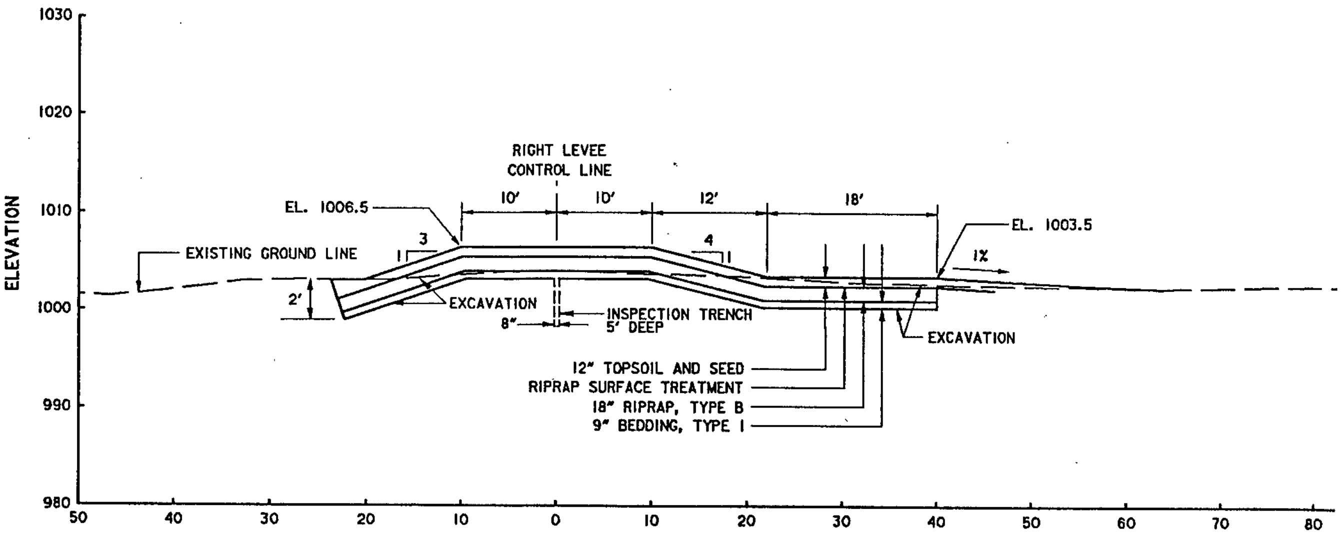
DATE: MAY 92

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

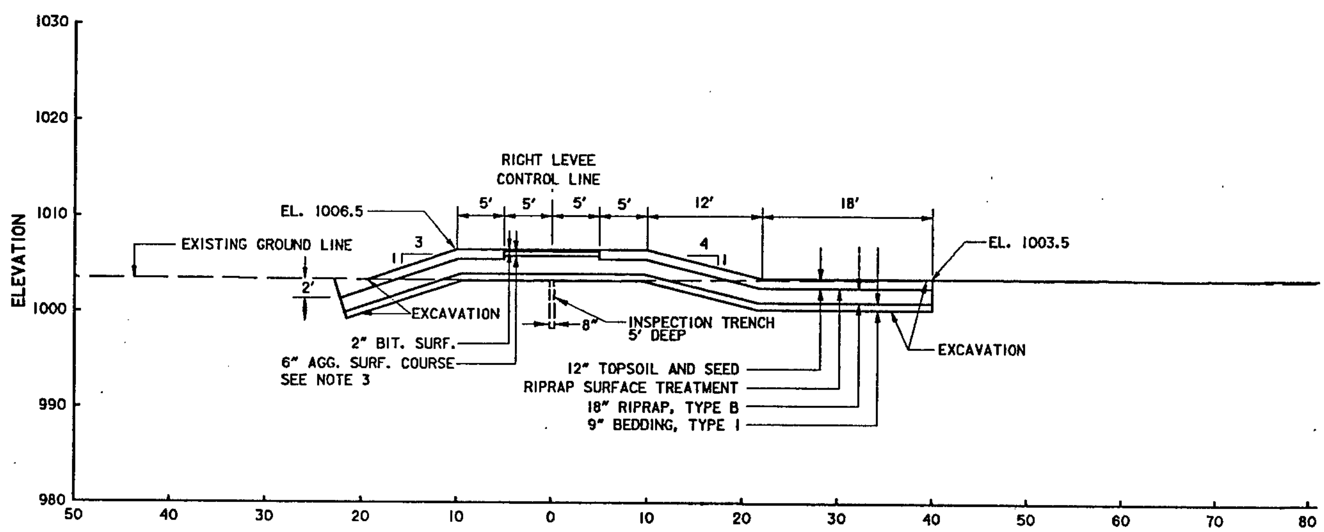
STAGE 4-BEAR CREEK

CHANNEL SECTIONS 31-33
STATION 71+80 TO 73+50

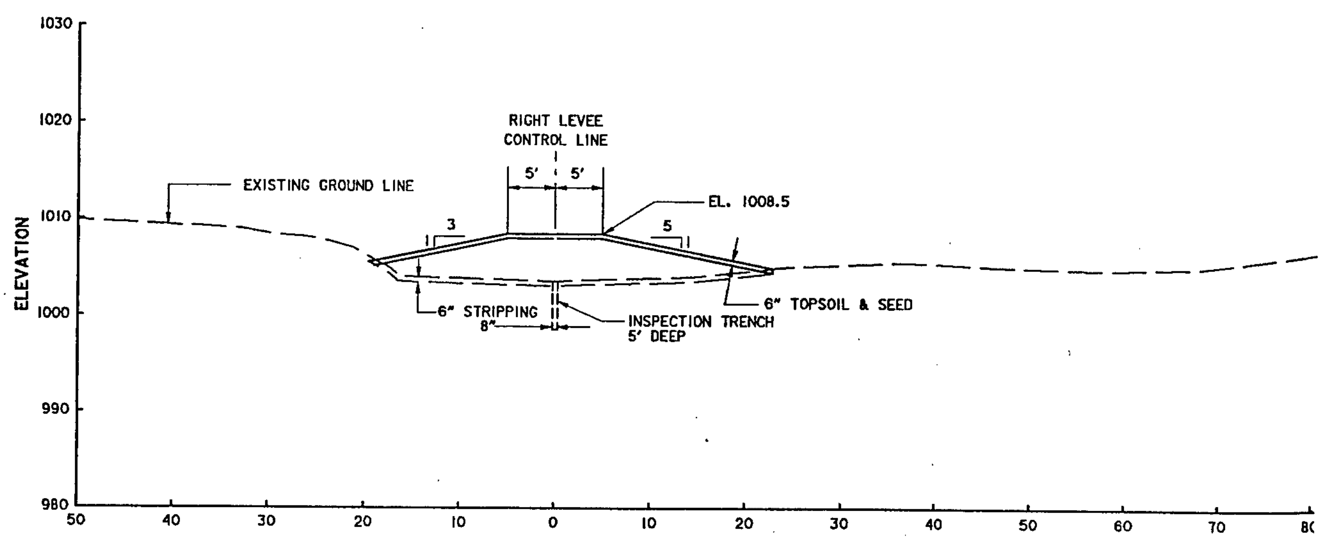
CAD FILE NAME: r4xs3133.dgn
SPEC NO:
DRAWING NUMBER: PLATE 25
SHT 25 OF 53



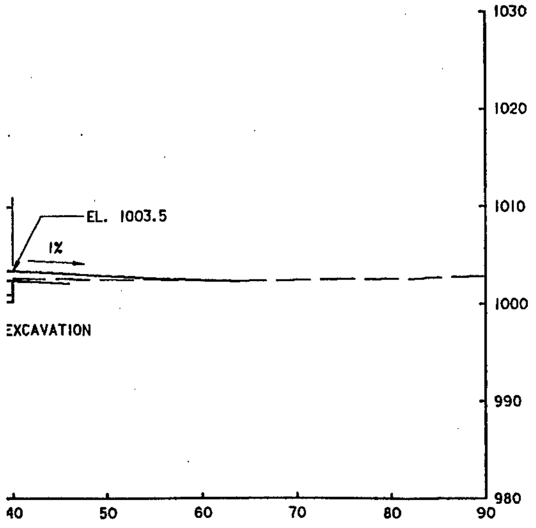
SECTION
STATION 0+50R
1

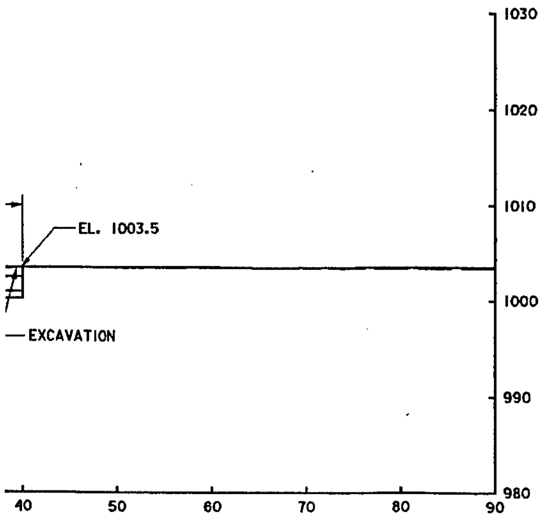


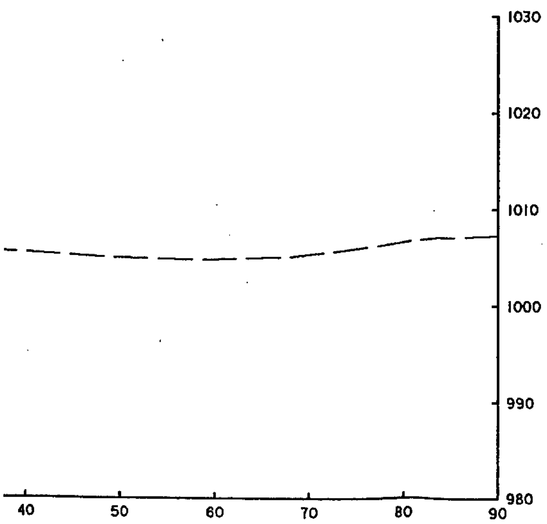
TYPICAL SECTION
STATION 0+60R TO 6+40R
2



TYPICAL SECTION
STATION 6+46R TO 9+35R
3







NOTES:

1. ELEVATION VARIES - SEE PR(
2. RIPRAP SURFACE TREATMENT (REQUIRED BETWEEN TOPSOIL A RIPRAP.
3. BIT. SURF. AND AGG.BASE COI REPLACED WITH 6" TOPSOIL A SEED FROM STA. 0+60R TO 2· AND 4+25R TO 6+40R.
4. CROSS SECTIONS ARE SHOWN LOOKING DOWN STATION.

SYMBOL	

AE APPROVING OFFICIAL:

FL

ED-D	DESIGNED: KFB/CAS	
	CHECKED: GVF	
	DRAWN: KFB/dae	
ED-GH	DESIGNED: FWC/DAC	
	CHECKED: SVD/MSM	CAD FILE NAME
DATE: MAY 92		SPEC NO:

NOTES:

1. ELEVATION VARIES - SEE PROFILE
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED BETWEEN TOPSOIL AND RIPRAP.
3. BIT. SURF. AND AGG.BASE COURSE REPLACED WITH 6" TOPSOIL AND SEED FROM STA. 0+60R TO 2+70R AND 4+25R TO 6+40R.
4. CROSS SECTIONS ARE SHOWN LOOKING DOWN STATION.

SYMBOL	DESCRIPTION	DATE	APPROVAL

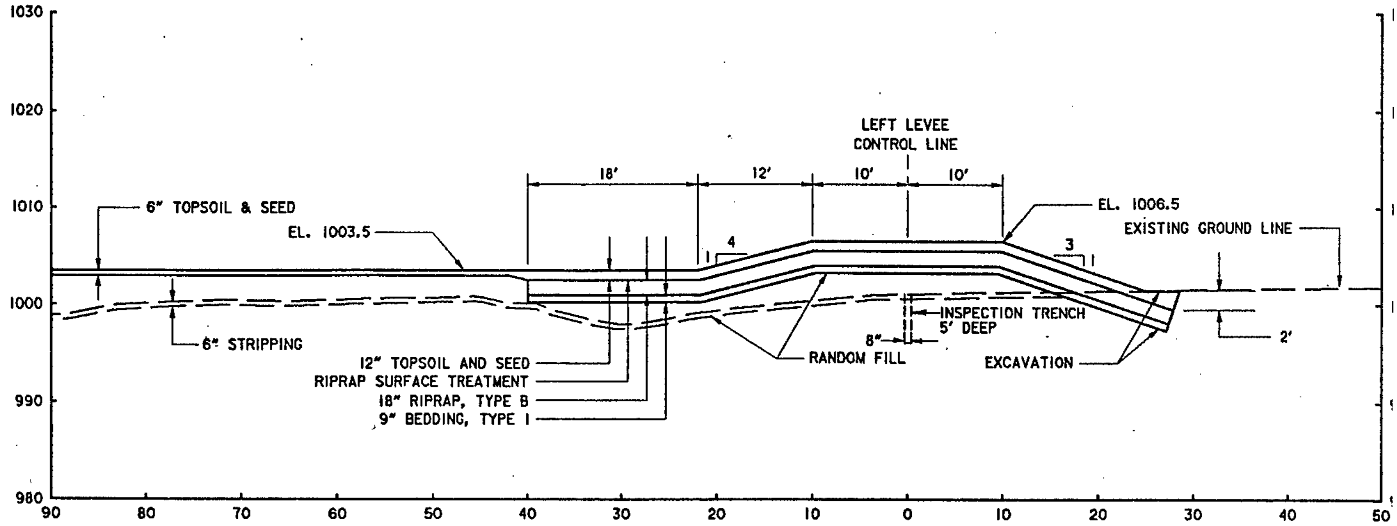
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

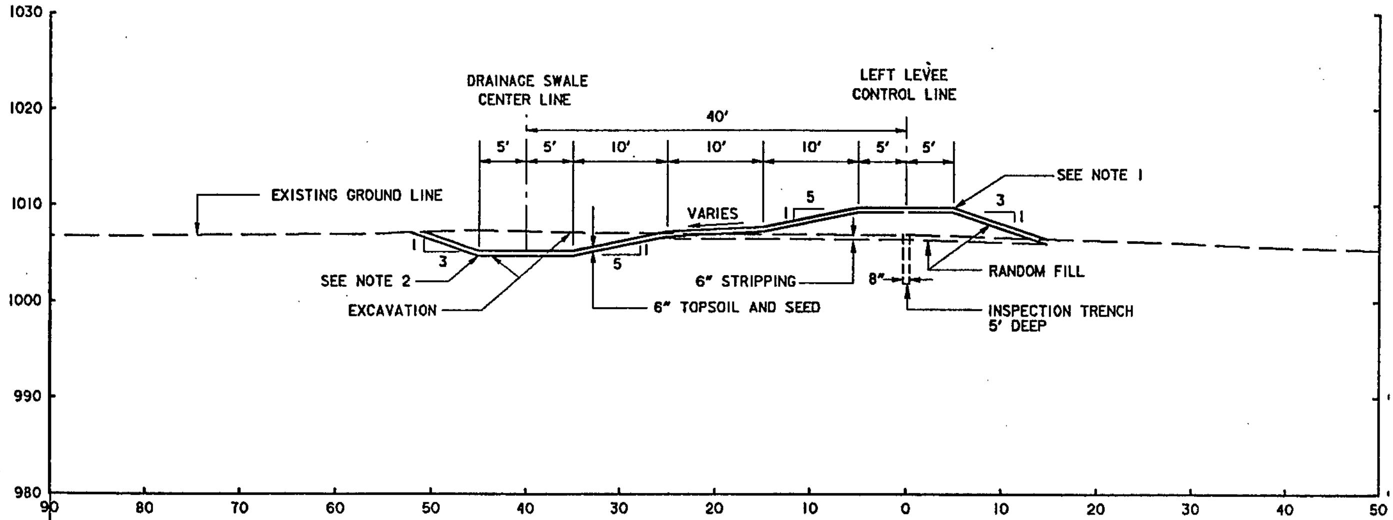
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
RIGHT LEVEE SECTIONS 1-3
STATION 0+71R TO 9+35R

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	KFB/dae
ED-GH	DESIGNED:	FWC/DAC
ED-GH	CHECKED:	SVD/MSM
DATE: MAY 92		

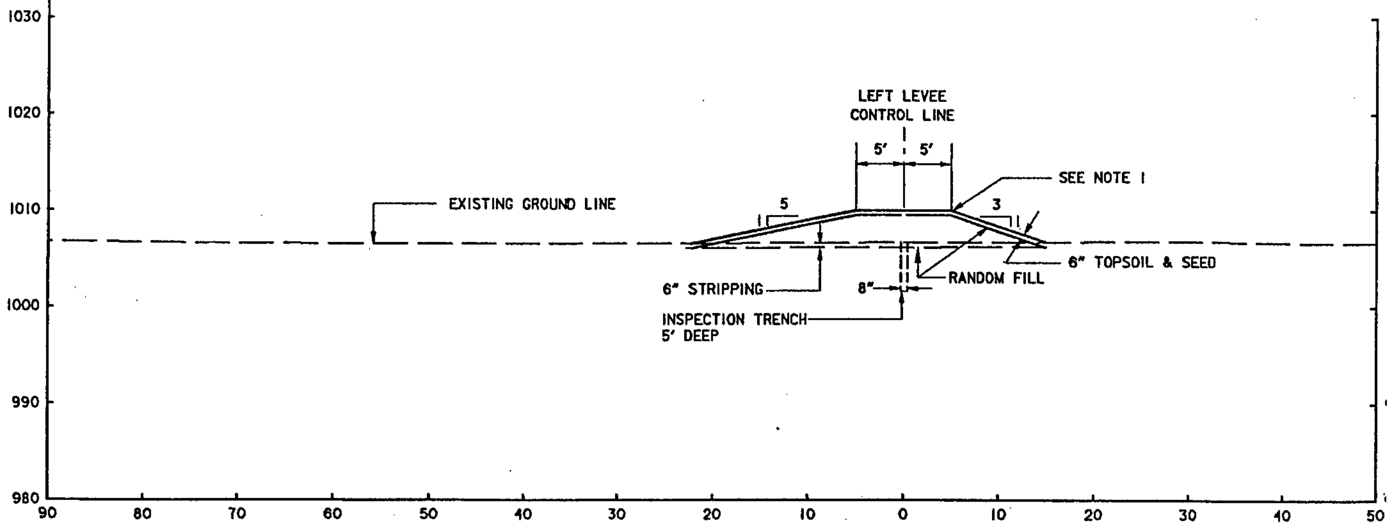
CAD FILE NAME: r4xsII.dgn
SPEC NO:
DRAWING NUMBER: PLATE 26
SHT 26 OF 53



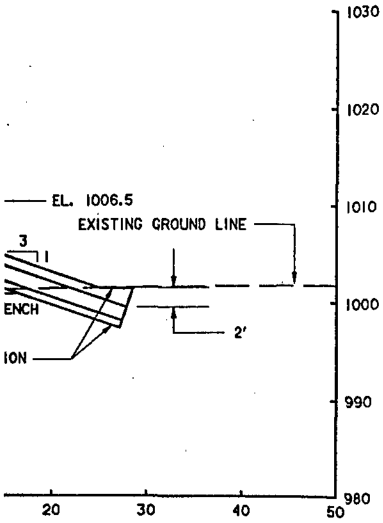
TYPICAL SECTION
STATION 0+71L TO 3+15L
1

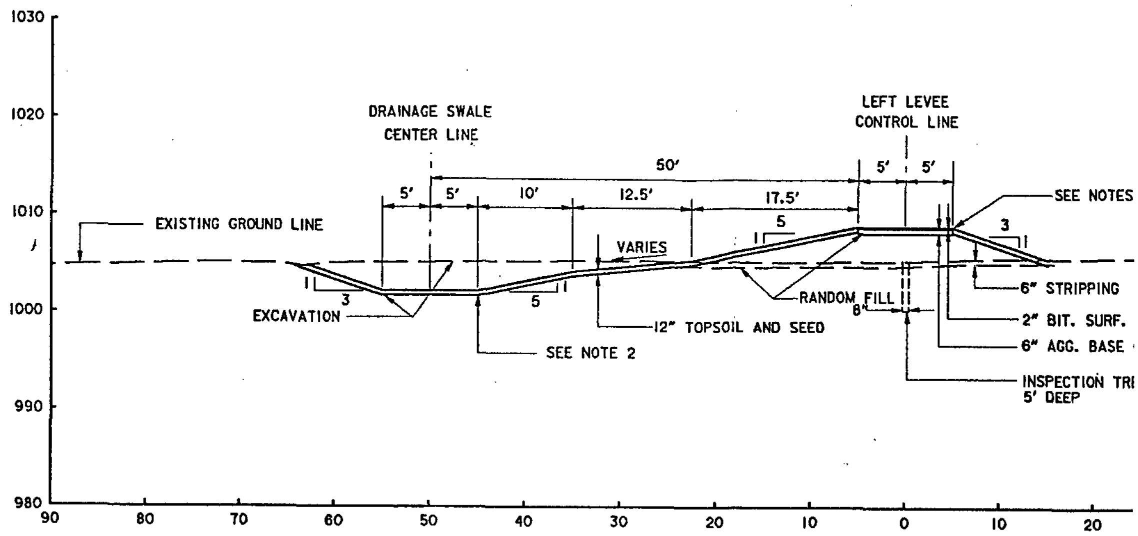


TYPICAL SECTION
STATION 20+55L TO 23+45L
3

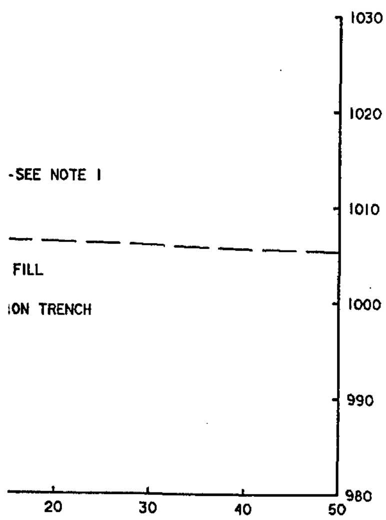


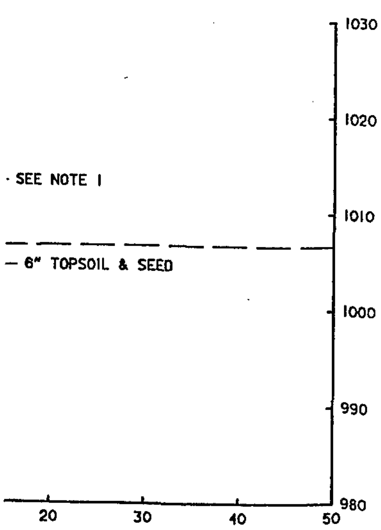
TYPICAL SECTION
STATION 25+20L TO 29+00L
4





TYPICAL SECTION 2
STATION 5+00L TO 16+50L





NOTES:

1. ELEVATION VARIES, SEE PROFILE.
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP.
3. BIT. SURFACE AND AGG. BASE COURSE REPLACED WITH 6" TOPSOIL AND SEED FROM STA. 16+50L TO 17+70L.
4. CROSS SECTIONS ARE SHOWN LOOKING DO STATION.

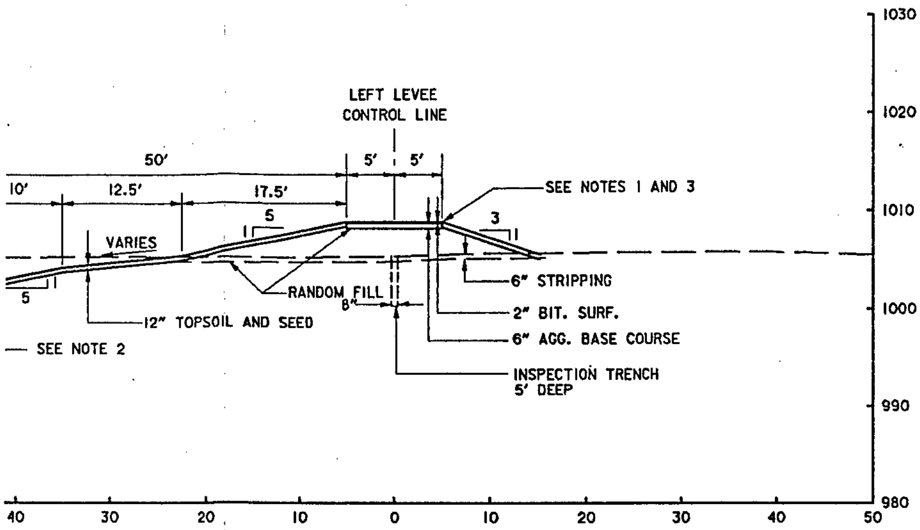
SYMBOL	DESCRIPTION

AE APPROVING OFFICIAL:

ED-D	DESIGNED: KFB/CAS
	CHECKED: GVF
	DRAWN: KFB/dae
ED-GH	DESIGNED: FWC/DAC
	CHECKED: SVD/MSM
DATE: MAY 92	

DES
FLOOD CONTRC
ROC
STA
LEFT
STATI

CAD FILE NAME: r4xsl2.dgn
SPEC NO:



TYPICAL SECTION 2
STATION 5+00L TO 16+50L

NOTES:

1. ELEVATION VARIES, SEE PROFILE.
2. RIPRAP SURFACE TREATMENT ONLY REQUIRED WHERE TOPSOIL IS PLACED OVER RIPRAP.
3. BIT. SURFACE AND AGG. BASE COURSE REPLACED WITH 6" TOPSOIL AND SEED FROM STA. 16+50L TO 17+70L.
4. CROSS SECTIONS ARE SHOWN LOOKING DOWN STATION.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

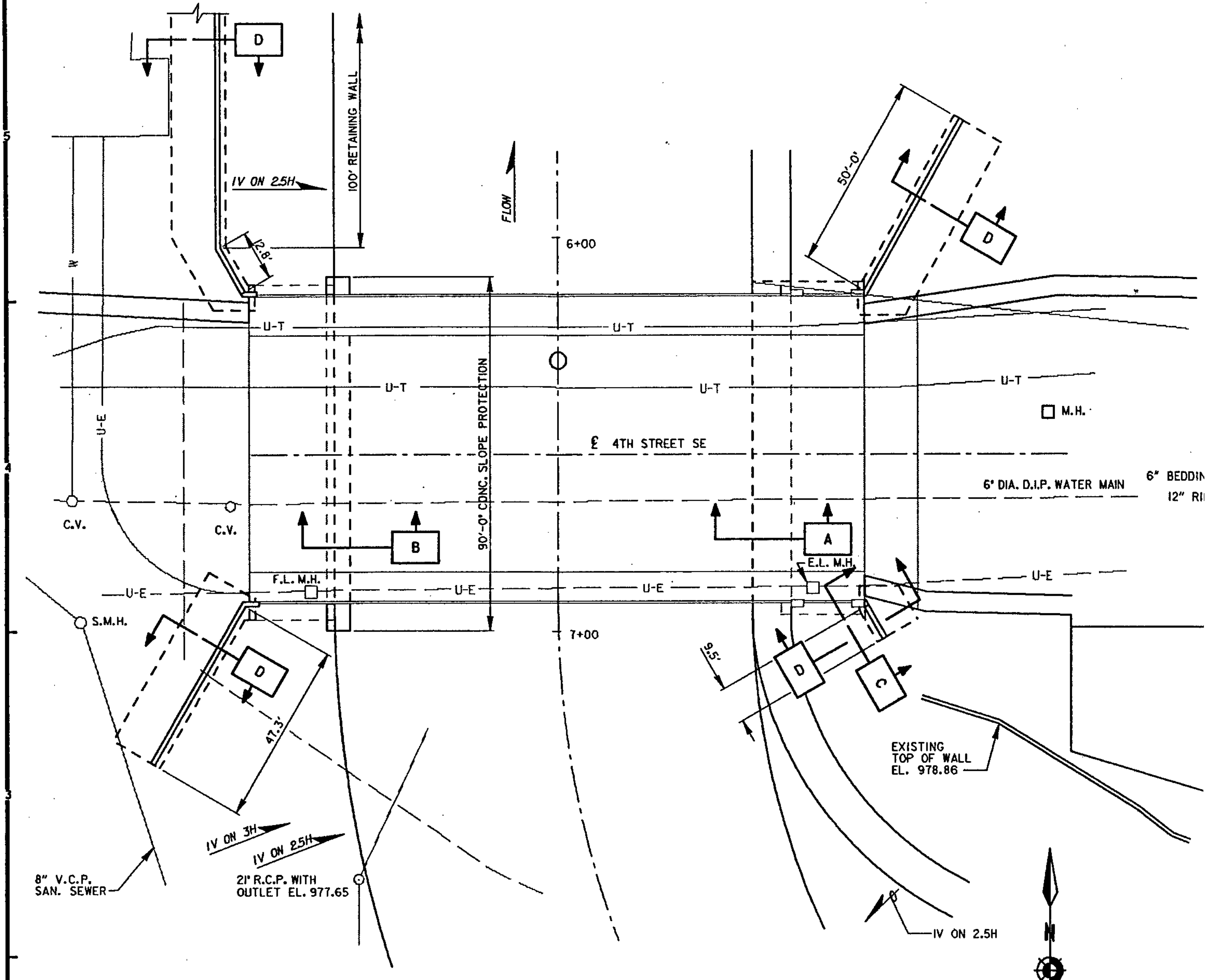
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

STAGE 4-BEAR CREEK
LEFT LEVEE SECTIONS 1-4
STATION 0+71L TO 29+00L

ED-D
DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: KFB/dae

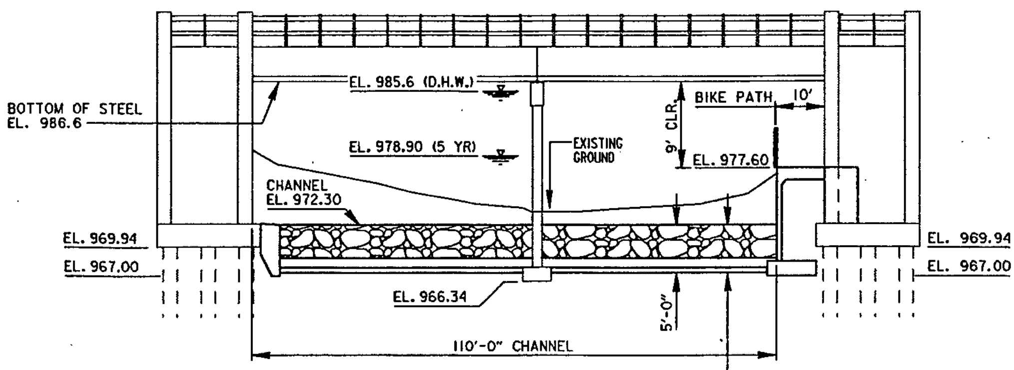
ED-GH
DESIGNED: FWC/DAC
CHECKED: SVD/MSM

DATE: MAY 92
CAD FILE NAME: r4xsl2.dgn
SPEC NO:
DRAWING NUMBER: PLATE 27
SHT 27 OF 53



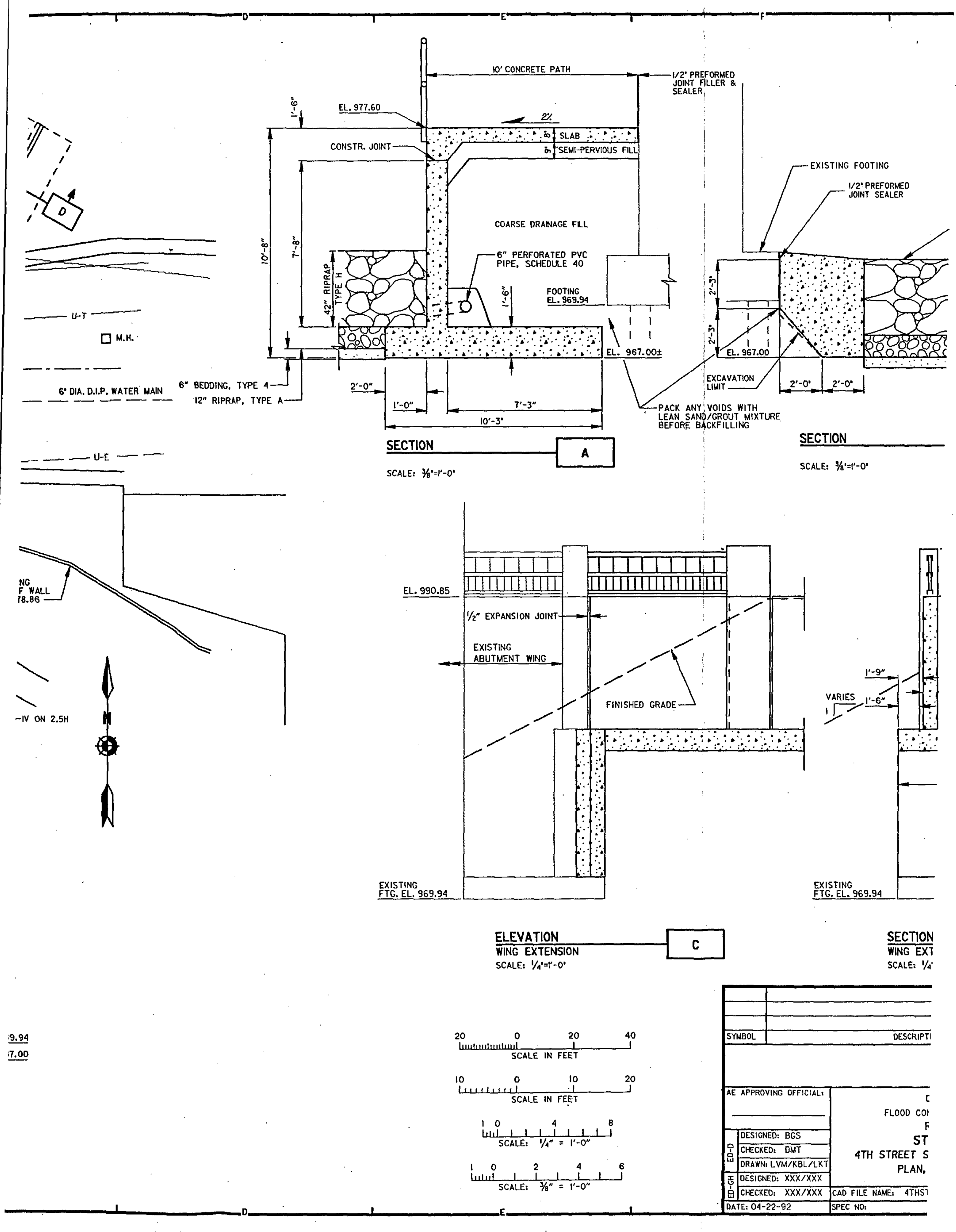
GENERAL - PLAN

SCALE: 1" = 20'-0"

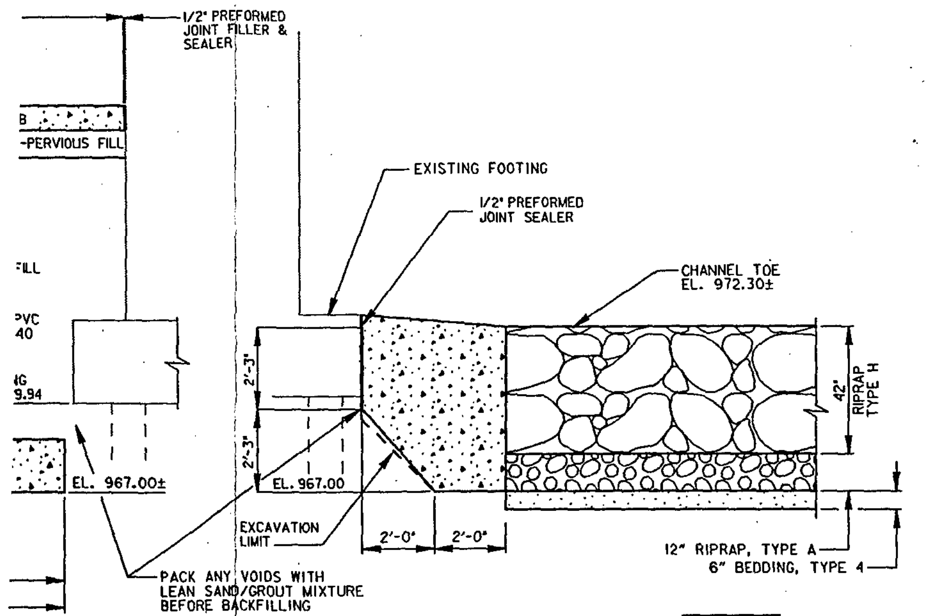


ELEVATION

SCALE: 1"=20' HORIZONTAL
1"=10' VERTICAL



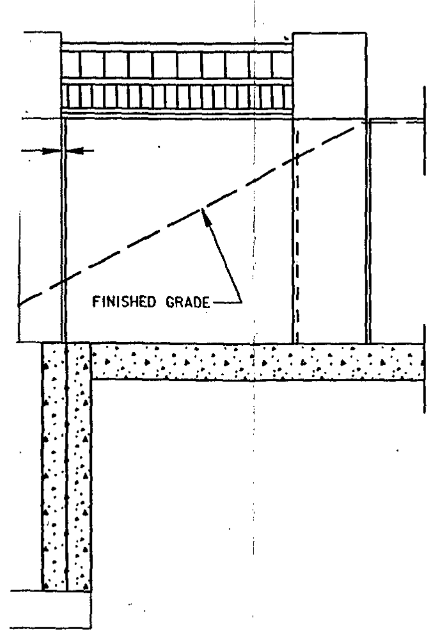
10' CONCRETE PATH
1/2" PREFORMED JOINT FILLER & SEALER
EL. 977.60
2%
SLAB
SEMI-PERVIOUS FILL
CONSTR. JOINT
COARSE DRAINAGE FILL
6" PERFORATED PVC PIPE, SCHEDULE 40
FOOTING EL. 969.94
42" RIPRAP TYPE H
10'-8"
7'-8"
1'-6"
EL. 967.00±
6" BEDDING, TYPE 4
12" RIPRAP, TYPE A
2'-0"
1'-0"
7'-3"
10'-3"
PACK ANY VOIDS WITH LEAN SAND/GROUT MIXTURE BEFORE BACKFILLING
EXISTING FOOTING
1/2" PREFORMED JOINT SEALER
2'-3"
EL. 967.00
EXCAVATION LIMIT
SECTION
A
SCALE: 3/8"=1'-0"
SECTION
SCALE: 3/8"=1'-0"
U-T
M.H.
6" DIA. D.I.P. WATER MAIN
U-E
-IV ON 2.5H
N
EL. 990.85
1/2" EXPANSION JOINT
EXISTING ABUTMENT WING
FINISHED GRADE
VARIES
1'-9"
1'-6"
EXISTING FTG. EL. 969.94
ELEVATION
WING EXTENSION
C
SCALE: 1/4"=1'-0"
SECTION
WING EXT
SCALE IN FEET
SCALE: 1/4" = 1'-0"
SCALE: 3/8" = 1'-0"
SYMBOL
DESCRIPTI
AE APPROVING OFFICIAL:
DESIGNED: BGS
CHECKED: DMT
DRAWN: LVM/KBL/LKT
DESIGNED: XXX/XXX
CHECKED: XXX/XXX
DATE: 04-22-92
FLOOD CO
4TH STREET S
PLAN,
CAD FILE NAME: 4THST
SPEC NO:

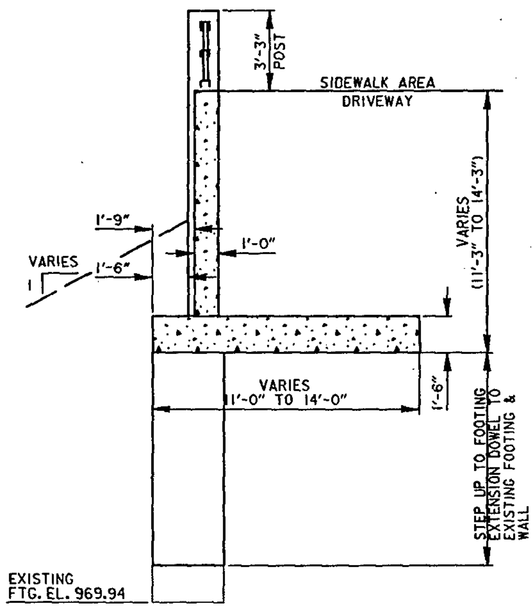


A

SECTION B

SCALE: 3/8"=1'-0"





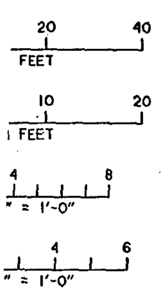
ISION C

-0"

SECTION D

WING EXTENSION

SCALE: 1/4"=1'-0"



SYMBOL	DESCRIPTION	DATE	APPROVAL

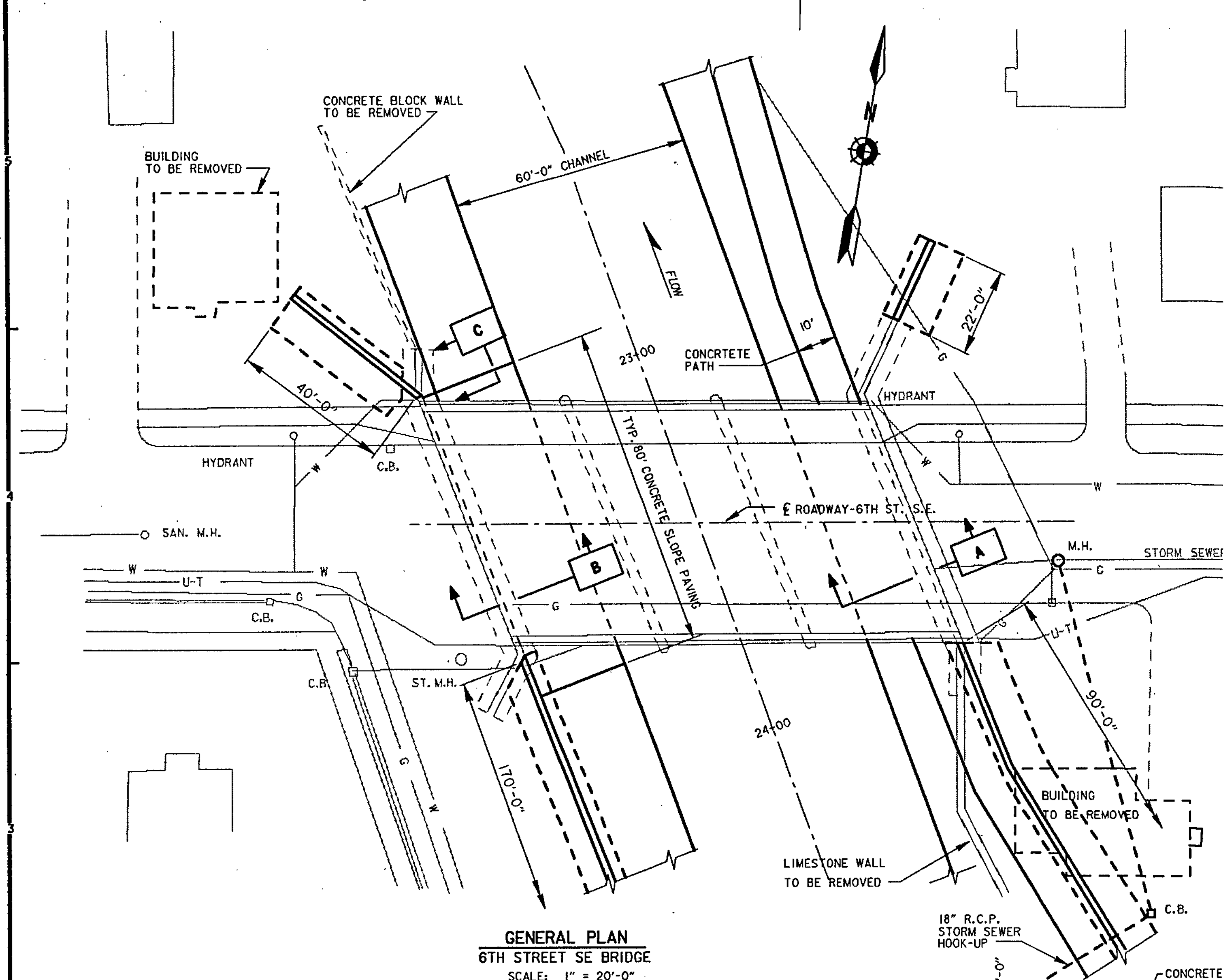
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

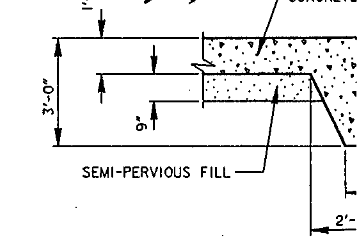
ED-D: DESIGNED: BGS; CHECKED: DMT; DRAWN: LVM/KBL/LKT
ED-GH: DESIGNED: XXX/XXX; CHECKED: XXX/XXX
DATE: 04-22-92

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
4TH STREET SE UNDERPASS & SCOUR PROTECTION
PLAN, ELEVATIONS AND SECTIONS

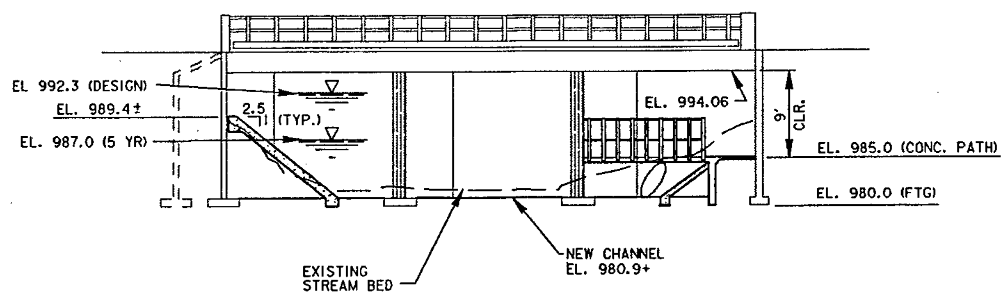
CAD FILE NAME: 4THST.DGN
SPEC NO:
DRAWING NUMBER: PLATE 28
SHT 28 OF 53



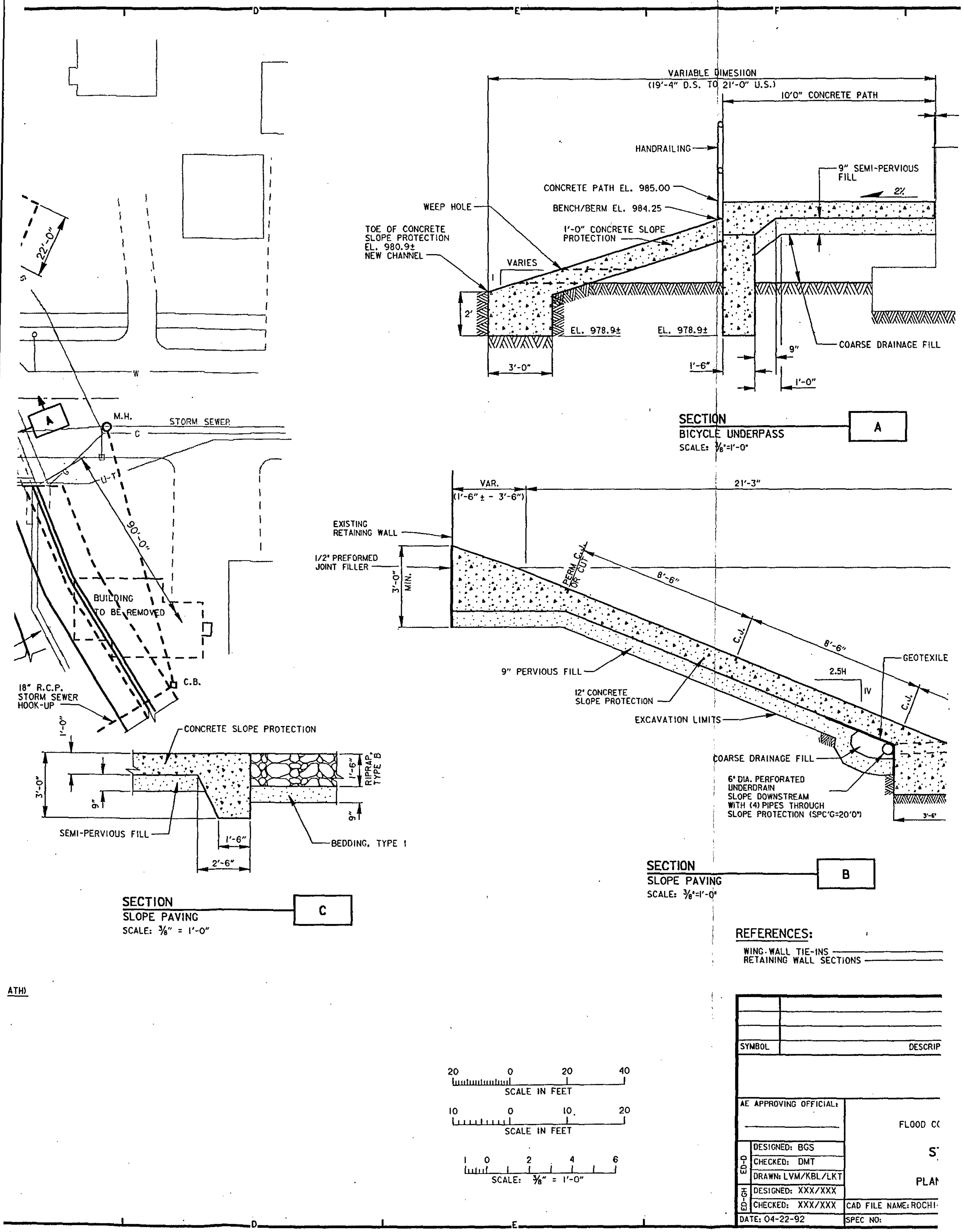
GENERAL PLAN
6TH STREET SE BRIDGE
SCALE: 1" = 20'-0"



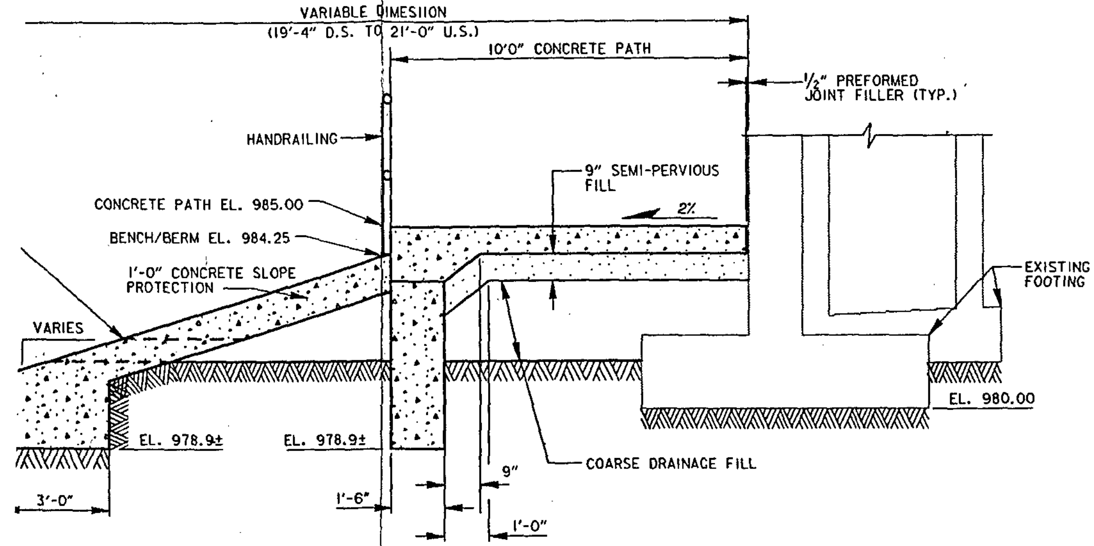
SECTION
SLOPE PAVING
SCALE: 3/8" = 1'-0"



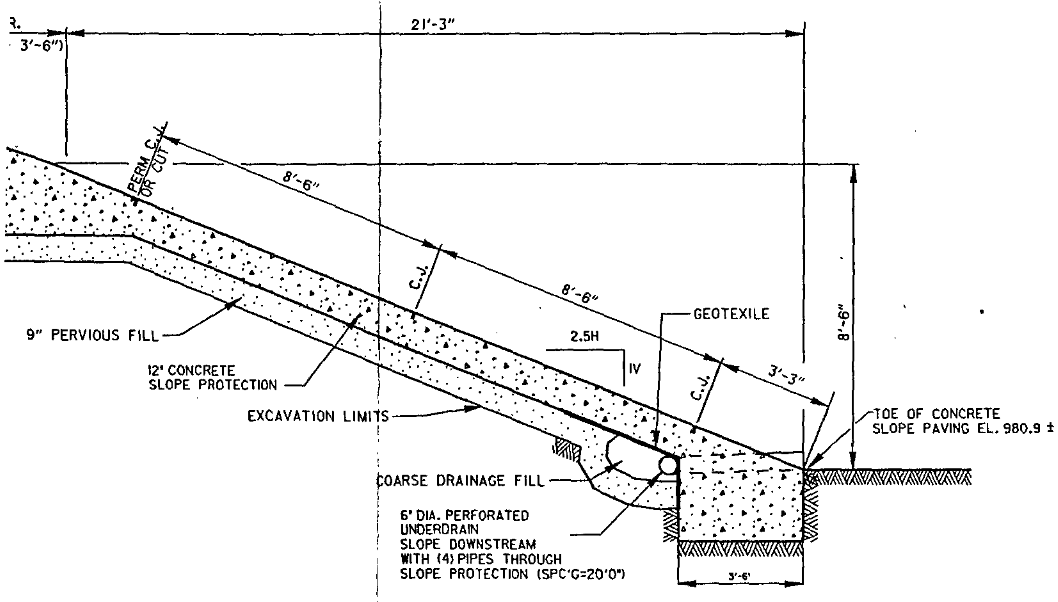
ELEVATION
SCALE: 1" = 20'-0" (HORIZONTAL)
SCALE: 1" = 10'-0" (VERTICAL)



D
E
F
22'-0"
90'-0"
M.H.
STORM SEWER
C
W
G
U-T
A
BUILDING
TO BE REMOVED
C.B.
18" R.C.P.
STORM SEWER
HOOK-UP
VARIABLE DIMESIION
(19'-4" D.S. TO 21'-0" U.S.)
10'0" CONCRETE PATH
HANDRAILING
9" SEMI-PERVIOUS
FILL
2%
CONCRETE PATH EL. 985.00
WEEP HOLE
BENCH/BERM EL. 984.25
TOE OF CONCRETE
SLOPE PROTECTION
EL. 980.9±
NEW CHANNEL
1'-0" CONCRETE SLOPE
PROTECTION
VARIES
2'
EL. 978.9±
EL. 978.9±
3'-0"
1'-6"
9"
1'-0"
COARSE DRAINAGE FILL
SECTION
BICYCLE UNDERPASS
SCALE: 3/8"=1'-0"
A
VAR.
(1'-6" ± - 3'-6")
21'-3"
EXISTING
RETAINING WALL
1/2" PREFORMED
JOINT FILLER
3'-0" MIN.
PERM C.J. OR CUT
8'-6"
C.J.
8'-6"
GEOTEXILE
2.5H
1V
C.J.
9" PERVIOUS FILL
12" CONCRETE
SLOPE PROTECTION
EXCAVATION LIMITS
COARSE DRAINAGE FILL
6" DIA. PERFORATED
UNDERDRAIN
SLOPE DOWNSTREAM
WITH (4) PIPES THROUGH
SLOPE PROTECTION (SPC'G=20'0")
3'-6"
SECTION
SLOPE PAVING
SCALE: 3/8"=1'-0"
B
CONCRETE SLOPE PROTECTION
1'-0"
3'-0"
9"
1'-6"
RIPRAP TYPE B
9"
SEMI-PERVIOUS FILL
BEDDING, TYPE 1
1'-6"
2'-6"
SECTION
SLOPE PAVING
SCALE: 3/8" = 1'-0"
C
REFERENCES:
WING-WALL TIE-INS
RETAINING WALL SECTIONS
ATH)
20 0 20 40
SCALE IN FEET
10 0 10 20
SCALE IN FEET
1 0 2 4 6
SCALE: 3/8" = 1'-0"
SYMBOL
DESCRIP
AE APPROVING OFFICIAL:
FLOOD CC
S
PLAN
ED-D
DESIGNED: BGS
CHECKED: DMT
DRAWN: LVM/KBL/LKT
ED-GH
DESIGNED: XXX/XXX
CHECKED: XXX/XXX
CAD FILE NAME: ROCHI-
DATE: 04-22-92
SPEC NO:



SECTION A
BICYCLE UNDERPASS
SCALE: ⅜"=1'-0"



SECTION B
SLOPE PAVING
SCALE: ⅜"=1'-0"

REFERENCES: **DWG. NO.**

WING-WALL TIE-INS ———— PLATE 30
RETAINING WALL SECTIONS ———— PLATE 31

SYMBOL	DESCRIPTION	DATE	APPROVAL

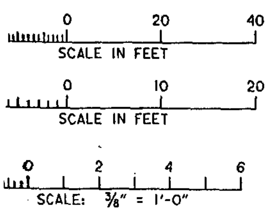
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

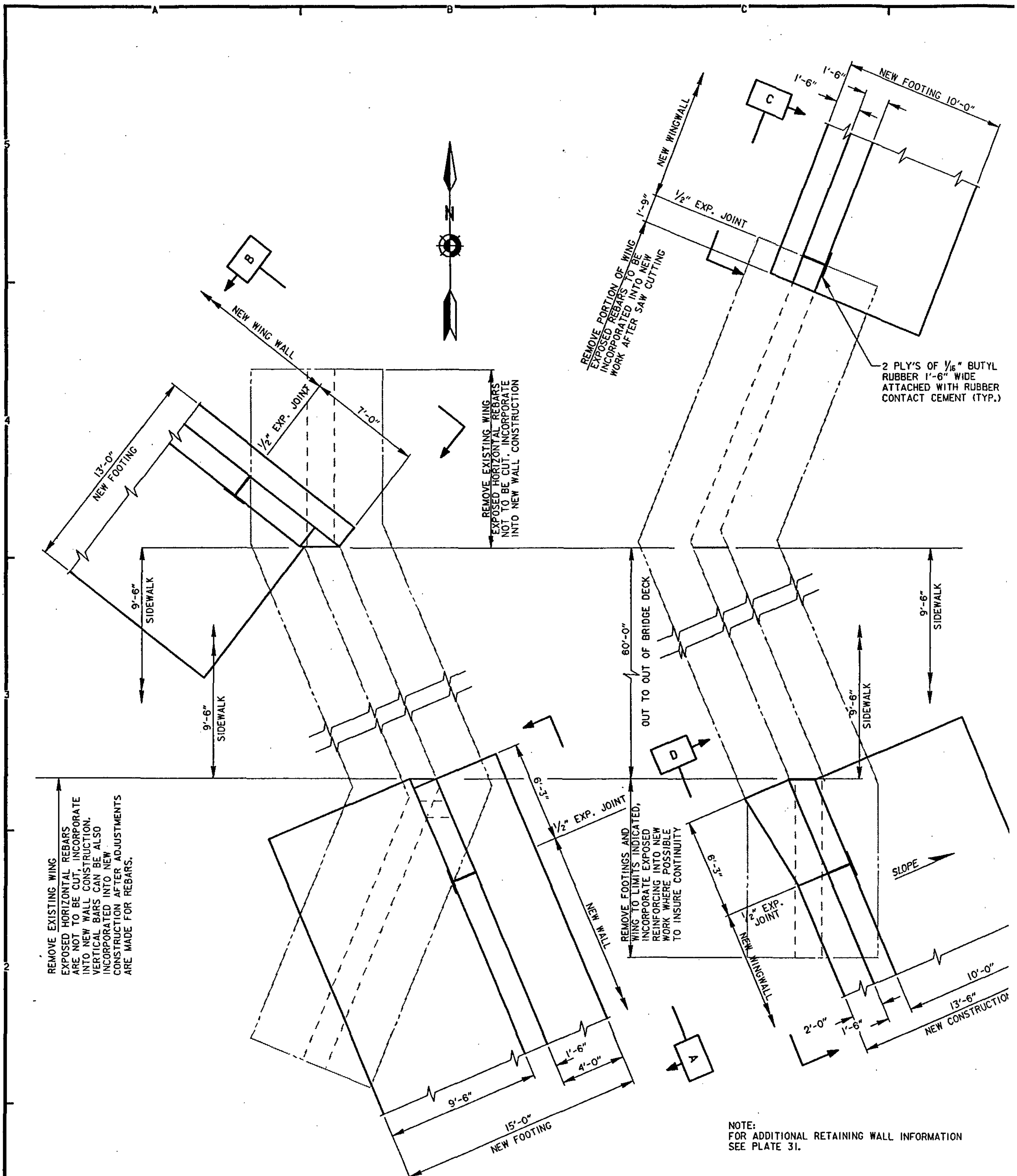
AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
6TH STREET BRIDGE
PLAN, ELEVATION AND SECTIONS

ED-D	DESIGNED: BGS
	CHECKED: DMT
	DRAWN: LVM/KBL/LKT
ED-GH	DESIGNED: XXX/XXX
	CHECKED: XXX/XXX
	DATE: 04-22-92

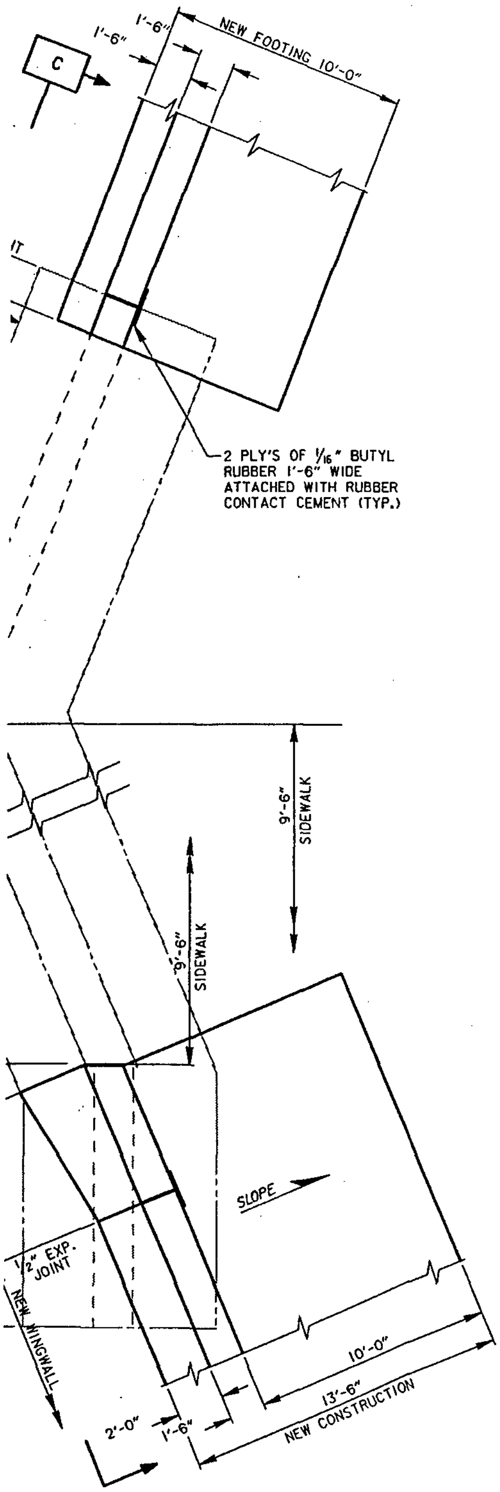
CAD FILE NAME: ROCH1-3.DGN
SPEC NO:
DRAWING NUMBER: PLATE 29
SHT 29 OF 53

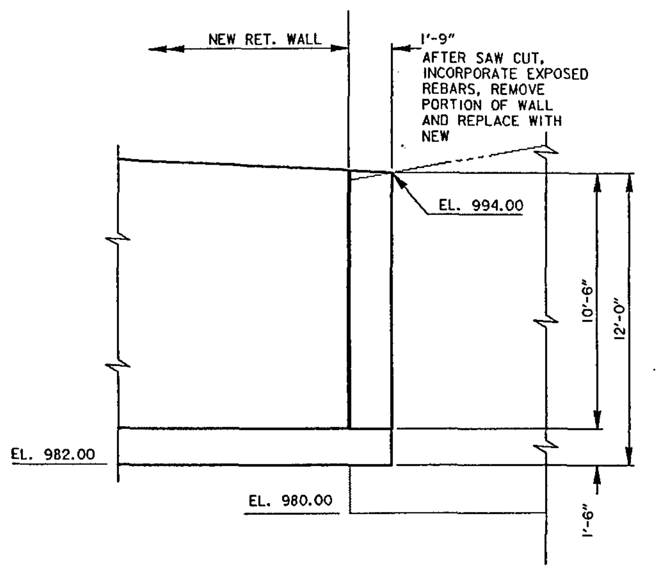




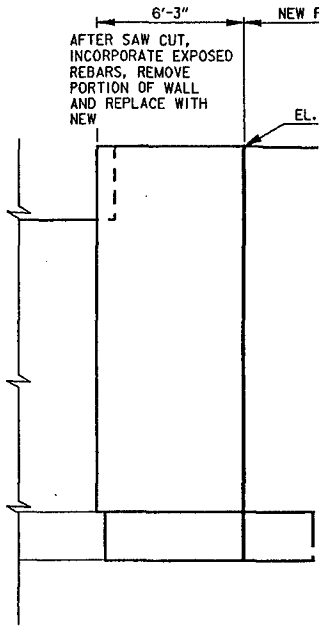
NOTE:
FOR ADDITIONAL RETAINING WALL INFORMATION SEE PLATE 31.

PLAN
ABUTMENT WING WALL TIE-INS
SCALE: 1/4" = 1'-0"

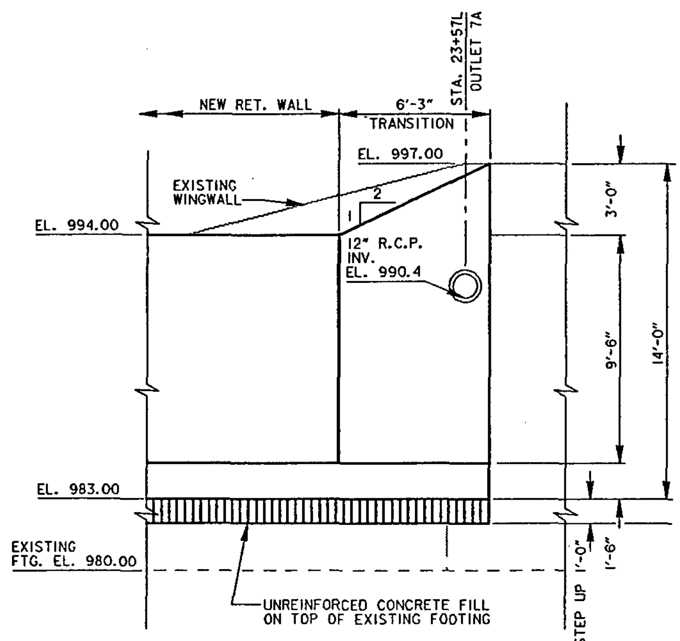




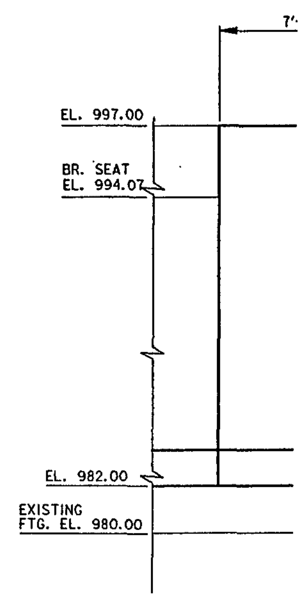
ELEVATION
NE WING EXTENSION TIE-IN
SCALE: 1/4"=1'-0"
C



ELEVATION
SE RETAINING WALL TI
SCALE: 1/4"=1'-0"



ELEVATION
SW RETAINING WALL TIE-IN
SCALE: 1/4"=1'-0"
A



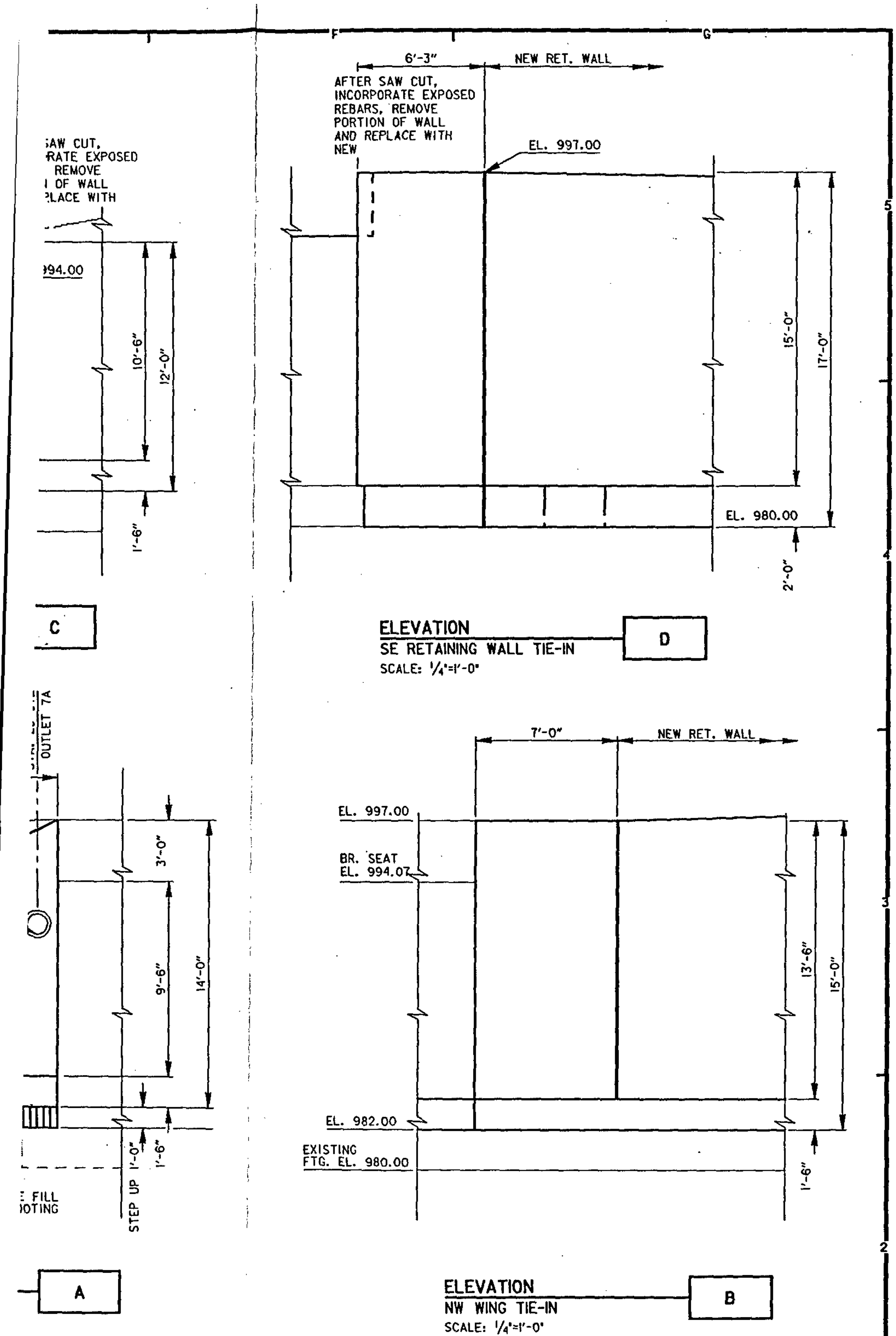
ELEVATION
NW WING TIE
SCALE: 1/4"=1'-C

IOTE:
'OR ADDITIONAL RETAINING WALL INFORMATION
;EE PLATE 31.

TIE-INS

0 4 8
SCALE: 1/4" = 1'-0"

SYMBOL	DE
AE APPROVING OFFICIAL:	FLOC
ED-D DESIGNED: BGS	
CHECKED: DMT	
DRAWN: WHP/LKT	
ED-GH DESIGNED: XXX/XXX	
CHECKED: XXX/XXX	CAD FILE NAME: W
DATE: 04-22-92	SPEC NO:



SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

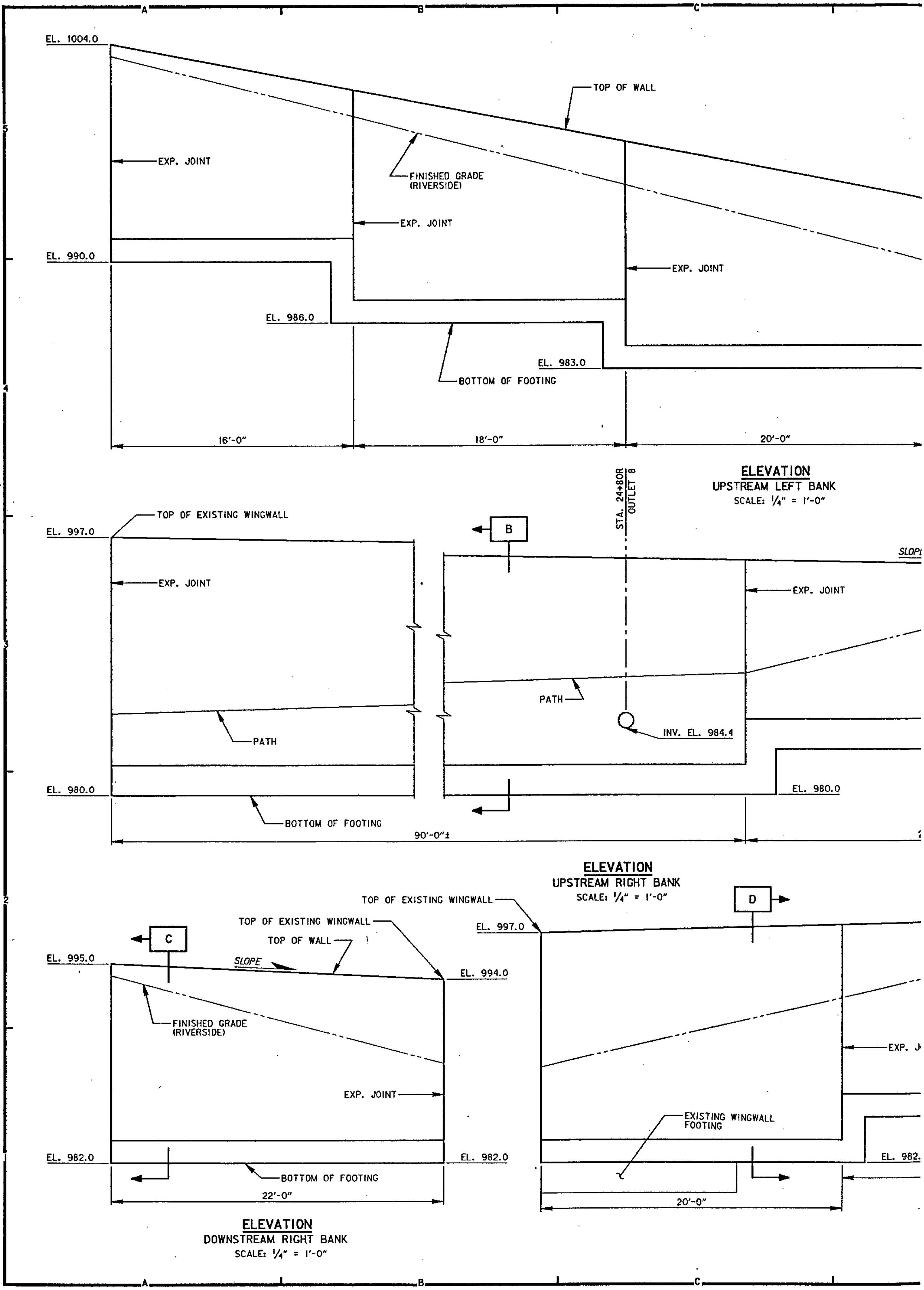
AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
6TH STREET BRIDGE WING WALLS
PLAN AND ELEVATIONS

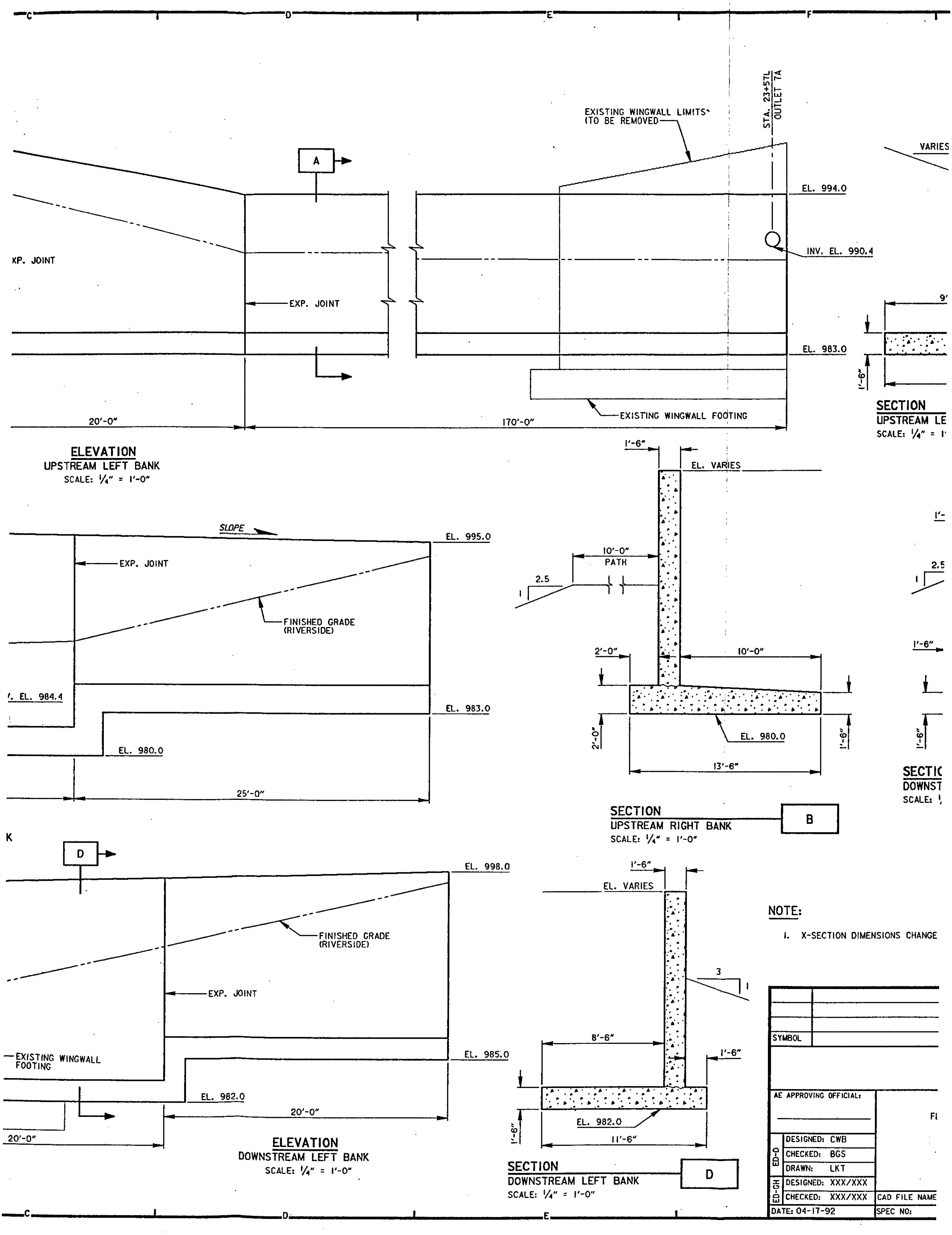
ED-D	DESIGNED:	BGS
ED-D	CHECKED:	DMT
ED-D	DRAWN:	WHP/LKT
ED-GH	DESIGNED:	XXX/XXX
ED-GH	CHECKED:	XXX/XXX

DATE: 04-22-92
CAD FILE NAME: WINGTIE.DGN
SPEC NO:
DRAWING NUMBER: PLATE 30
SHT 30 OF 53

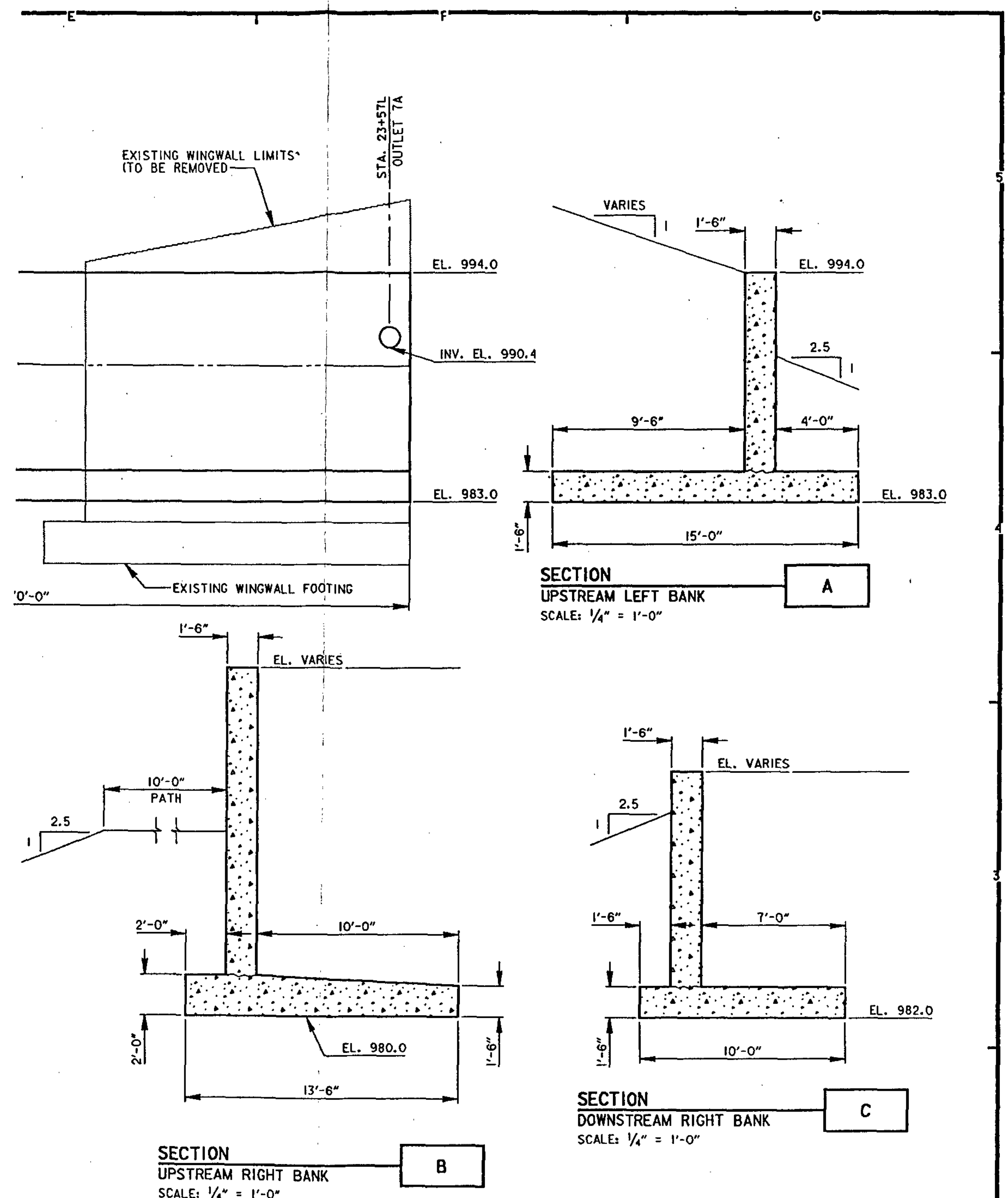
0 4 8
SCALE: 1/4" = 1'-0"

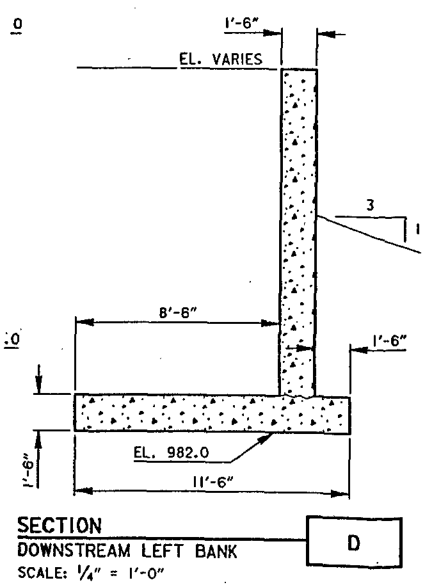


EL. 1004.0
TOP OF WALL
EXP. JOINT
FINISHED GRADE (RIVERSIDE)
EXP. JOINT
EL. 990.0
EXP. JOINT
EL. 986.0
EL. 983.0
BOTTOM OF FOOTING
16'-0"
18'-0"
20'-0"
STA. 24+80R OUTLET 8
ELEVATION
UPSTREAM LEFT BANK
SCALE: 1/4" = 1'-0"
TOP OF EXISTING WINGWALL
EL. 997.0
B
EXP. JOINT
EXP. JOINT
PATH
PATH
INV. EL. 984.4
EL. 980.0
EL. 980.0
BOTTOM OF FOOTING
90'-0"±
ELEVATION
UPSTREAM RIGHT BANK
SCALE: 1/4" = 1'-0"
TOP OF EXISTING WINGWALL
D
TOP OF EXISTING WINGWALL
C
TOP OF WALL
EL. 997.0
EL. 995.0
SLOPE
EL. 994.0
FINISHED GRADE (RIVERSIDE)
EXP. JOINT
EXISTING WINGWALL FOOTING
EL. 982.0
EL. 982.0
BOTTOM OF FOOTING
22'-0"
20'-0"
ELEVATION
DOWNSTREAM RIGHT BANK
SCALE: 1/4" = 1'-0"



C
D
E
F
STA. 23+57L
OUTLET 7A
EXISTING WINGWALL LIMITS
(TO BE REMOVED)
A
VARIES
EL. 994.0
XP. JOINT
INV. EL. 990.4
EXP. JOINT
9'
EL. 983.0
1'-6"
EXISTING WINGWALL FOOTING
20'-0"
170'-0"
SECTION
UPSTREAM LE
SCALE: 1/4" = 1'
ELEVATION
UPSTREAM LEFT BANK
SCALE: 1/4" = 1'-0"
1'-6"
EL. VARIES
SLOPE
EL. 995.0
EXP. JOINT
10'-0"
PATH
2.5
1
FINISHED GRADE
(RIVERSIDE)
2'-0"
10'-0"
EL. 984.4
EL. 983.0
EL. 980.0
EL. 980.0
2'-0"
1'-6"
13'-6"
25'-0"
SECTION
UPSTREAM RIGHT BANK
SCALE: 1/4" = 1'-0"
B
SECTIC
DOWNST
SCALE:
K
D
EL. 998.0
1'-6"
EL. VARIES
NOTE:
1. X-SECTION DIMENSIONS CHANGE
FINISHED GRADE
(RIVERSIDE)
3
1
EXP. JOINT
SYMBOL
8'-6"
EL. 985.0
EXISTING WINGWALL
FOOTING
1'-6"
EL. 982.0
20'-0"
AE APPROVING OFFICIAL:
EL. 982.0
1'-6"
11'-6"
20'-0"
ELEVATION
DOWNSTREAM LEFT BANK
SCALE: 1/4" = 1'-0"
SECTION
DOWNSTREAM LEFT BANK
SCALE: 1/4" = 1'-0"
D
ED-D
DESIGNED: CWB
CHECKED: BGS
DRAWN: LKT
ED-GH
DESIGNED: XXX/XXX
CHECKED: XXX/XXX
CAD FILE NAME
DATE: 04-17-92
SPEC NO:





NOTE:

1. X-SECTION DIMENSIONS CHANGE WHEN THE FOOTINGS STEP UP.

SYMBOL	DESCRIPTION	DATE	APPROVAL

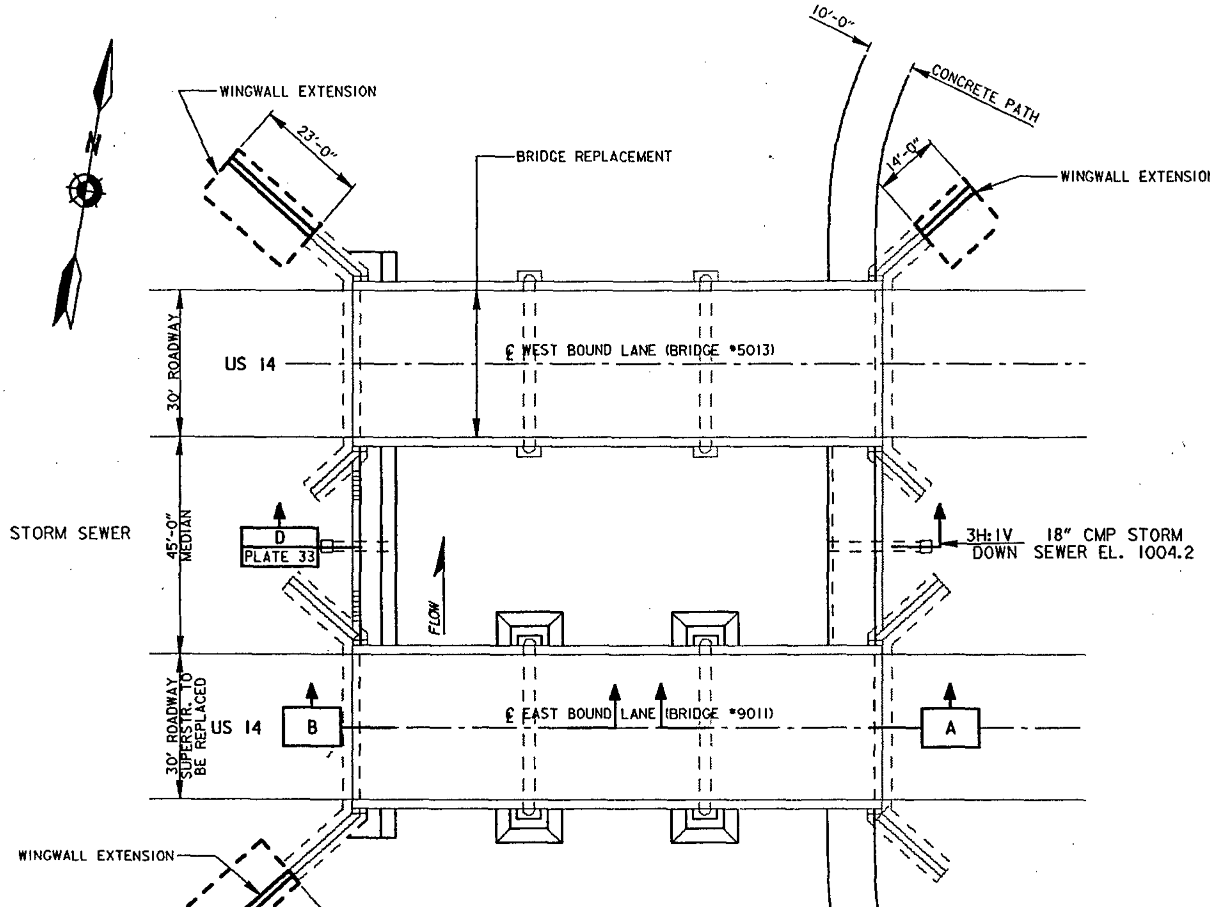
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
RETAINING WALLS
ELEVATIONS AND SECTIONS

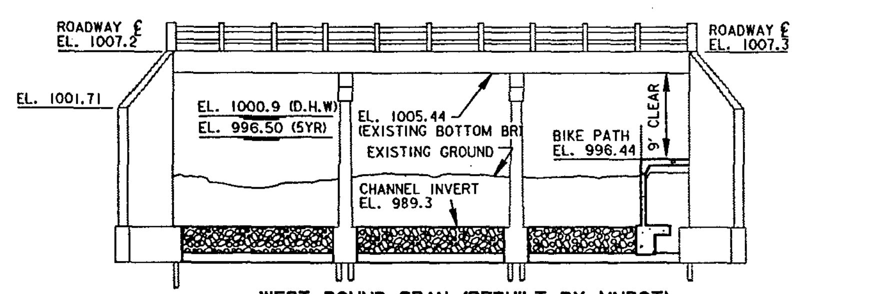
ED-D	DESIGNED:	CWB
	CHECKED:	BGS
	DRAWN:	LKT
ED-GH	DESIGNED:	XXX/XXX
	CHECKED:	XXX/XXX

DATE: 04-17-92 | CAD FILE NAME: ROCH4-6.DGN | SPEC NO: | DRAWING NUMBER: PLATE 31 | SHT 31 OF 53



PLAN

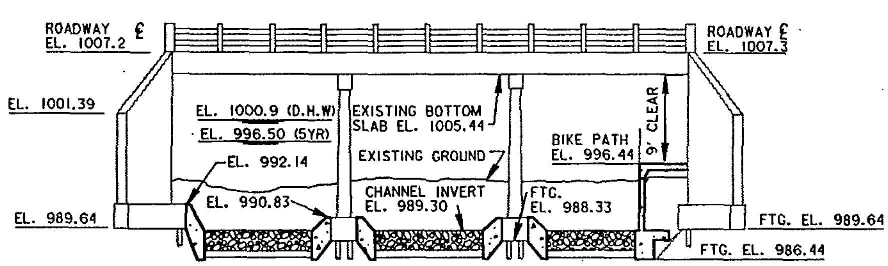
SCALE: 1" = 20'-0"



WEST BOUND SPAN (REBUILT BY MNDOT)

ROUTE 14 - BRIDGE *5013

SCALE: 1"=20'-0" HOR.;1"=10'-0" VERT.



EAST BOUND SPAN

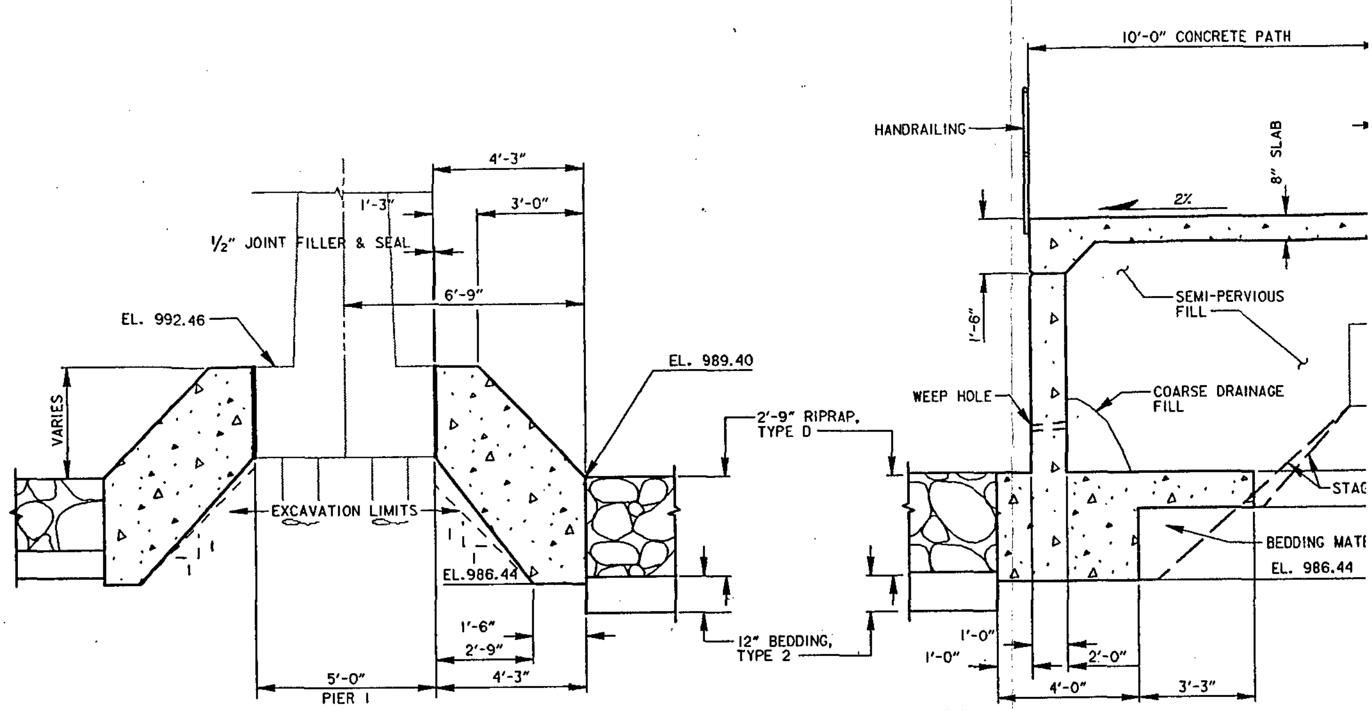
ROUTE 14 - BRIDGE *9011

SCALE: 1"=20'-0" HOR.;1"=10'-0" VERT.

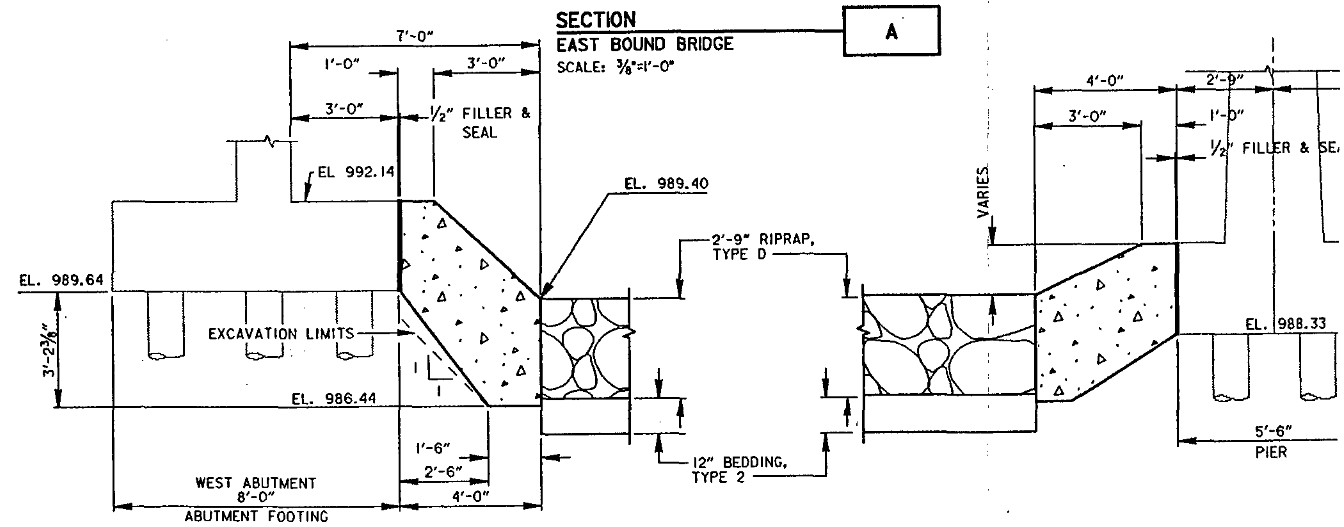
-WINGWALL EXTENSION

18" CMP STORM
SEWER EL. 1004.2

.64



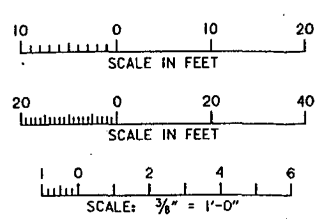
SECTION A
EAST BOUND BRIDGE
SCALE: 3/8"=1'-0"



SECTION B
EAST BOUND BRIDGE
SCALE: 3/8"=1'-0"

REFERENCES:

DETAILS



SYMBOL

AE APPROVING OFFICIAL:

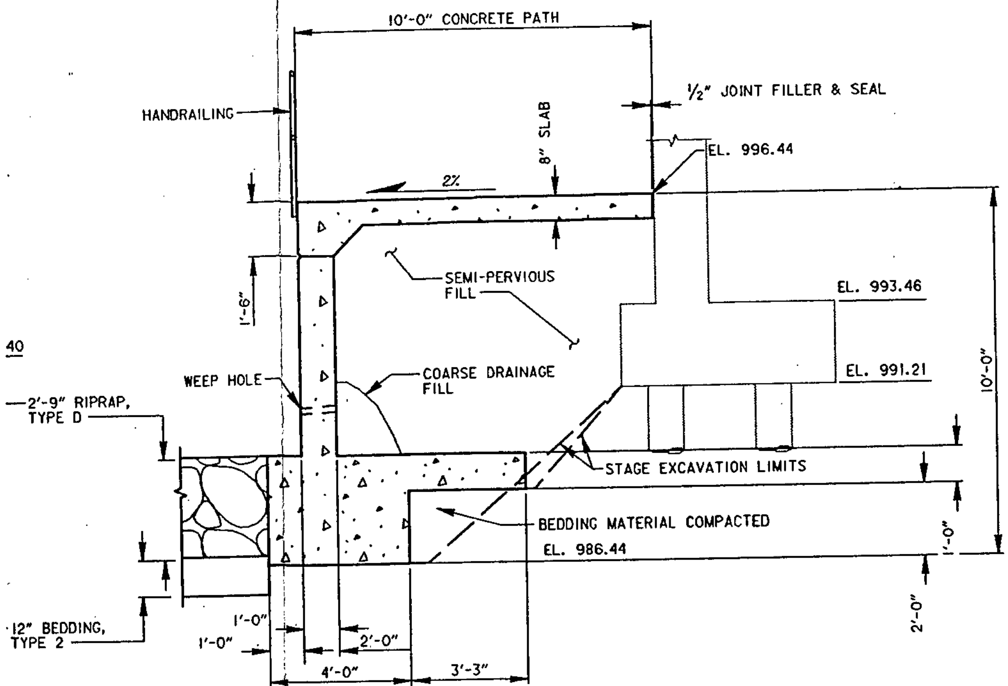
ED-D DESIGNED: BGS
CHECKED: DMT
DRAWN: LKT

ED-GH DESIGNED: XXX/XXX
CHECKED: XXX/XXX

CAD FILE NAME:

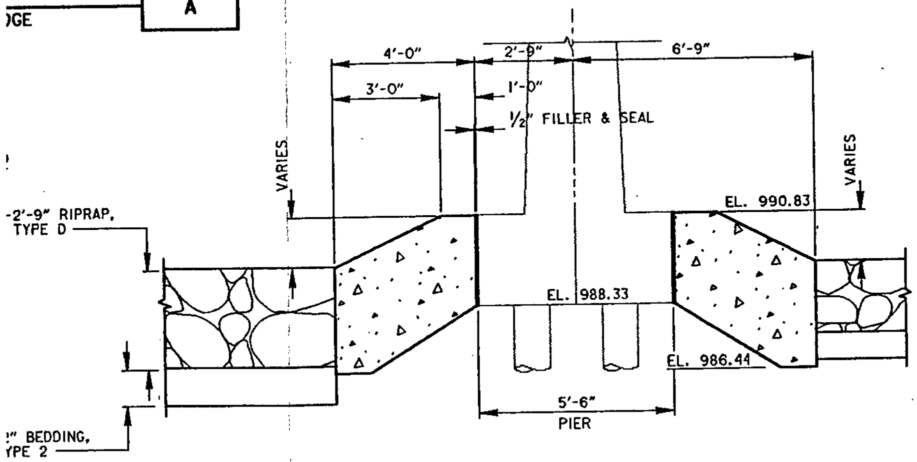
DATE: 04-27-92

SPEC NO:



A

)GE



B

IDGE

REFERENCES: **DWG. NO.**

DETAILS ———————————————— PLATE 33

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
U.S. 14 BRIDGE
PLAN, ELEVATIONS AND SECTIONS

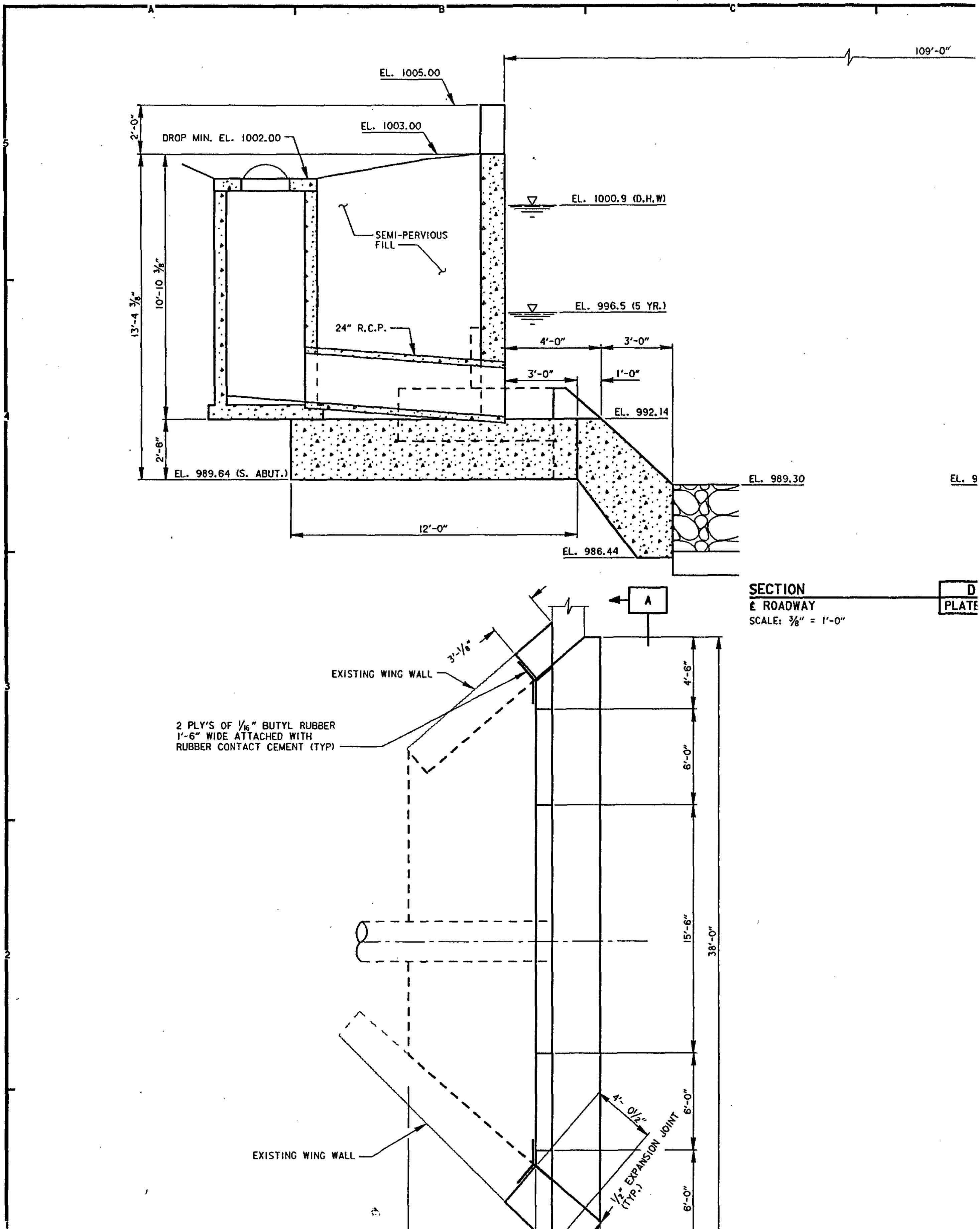
ED-D	DESIGNED:	BGS
	CHECKED:	DMT
	DRAWN:	LKT
ED-GH	DESIGNED:	XXX/XXX
	CHECKED:	XXX/XXX
DATE: 04-27-92		

CAD FILE NAME: ZS-PLAN.DGN
SPEC NO:
DRAWING NUMBER: PLATE 32
SHT 32 OF 53

10 0 10 20
SCALE IN FEET

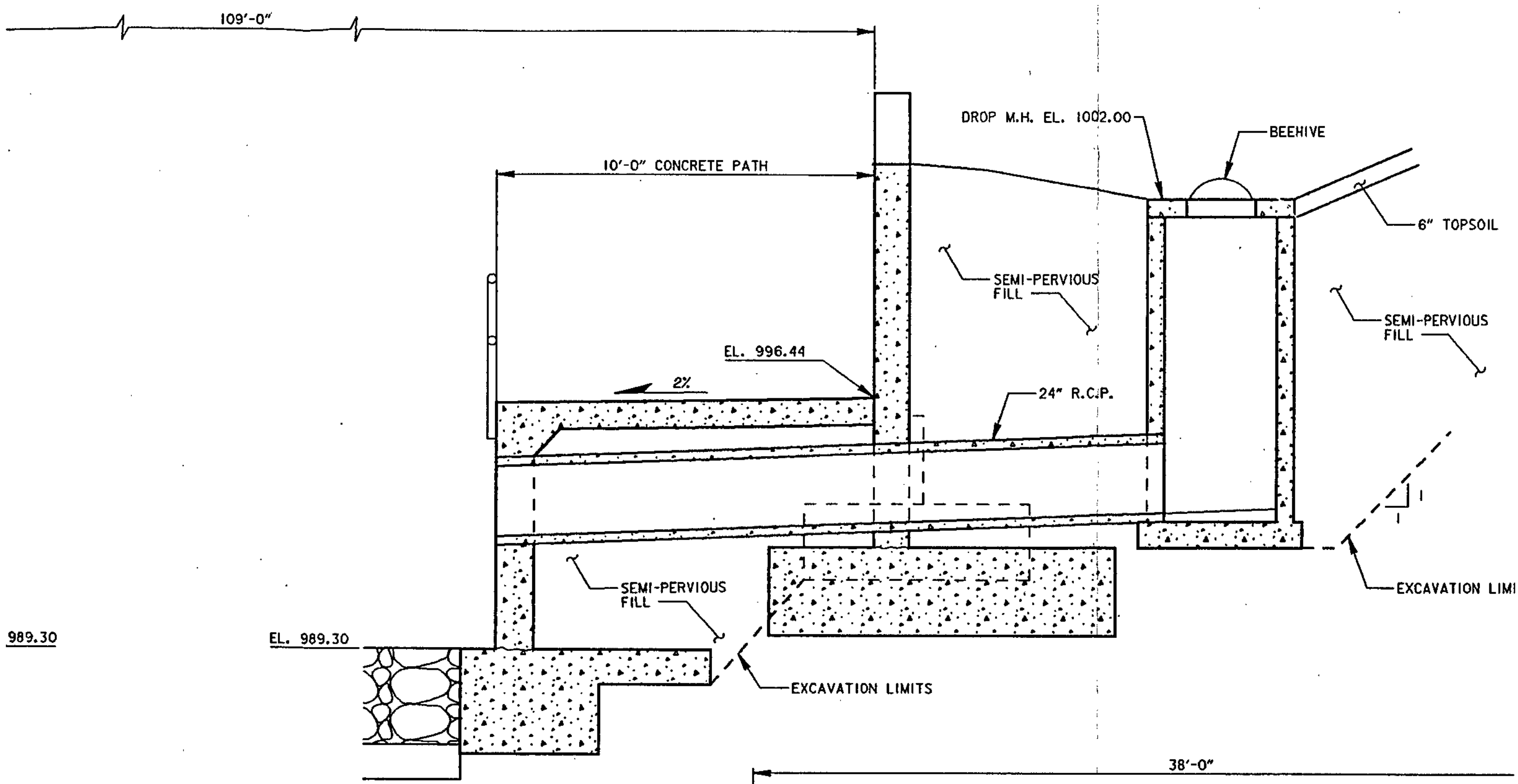
20 0 20 40
SCALE IN FEET

1 0 2 4 6
SCALE: ⅜" = 1'-0"



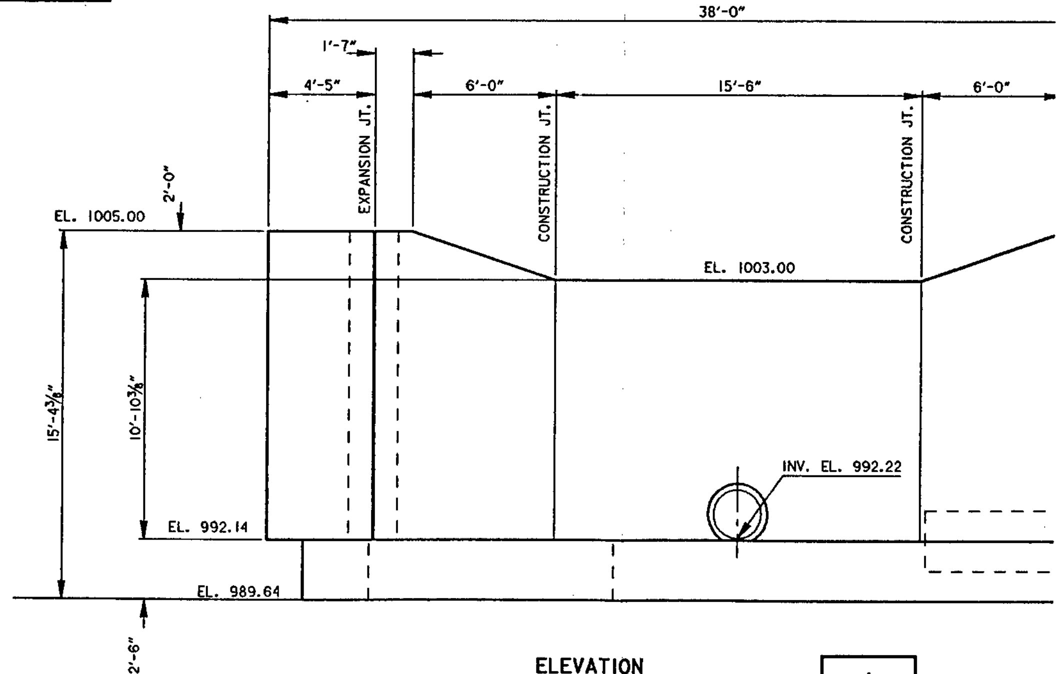
SECTION
℄ ROADWAY
SCALE: 3/8" = 1'-0"

PLAN
RETAINING WALL
SCALE: 1/4" = 1'-0"



:TION
OADWAY
.E: 3/8" = 1'-0"

D
PLATE 32



ELEVATION
WALL
SCALE: 1/4" = 1'-0"

A

0 2 4 6
SCALE: 3/8" = 1'-0"

0 4 8
SCALE: 1/4" = 1'-0"

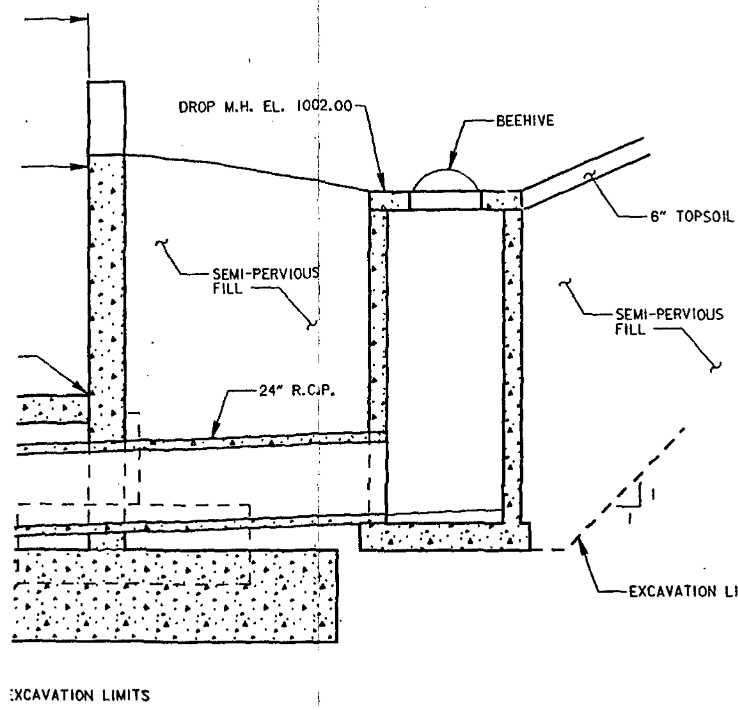
SYMBOL	DESCRIPTION

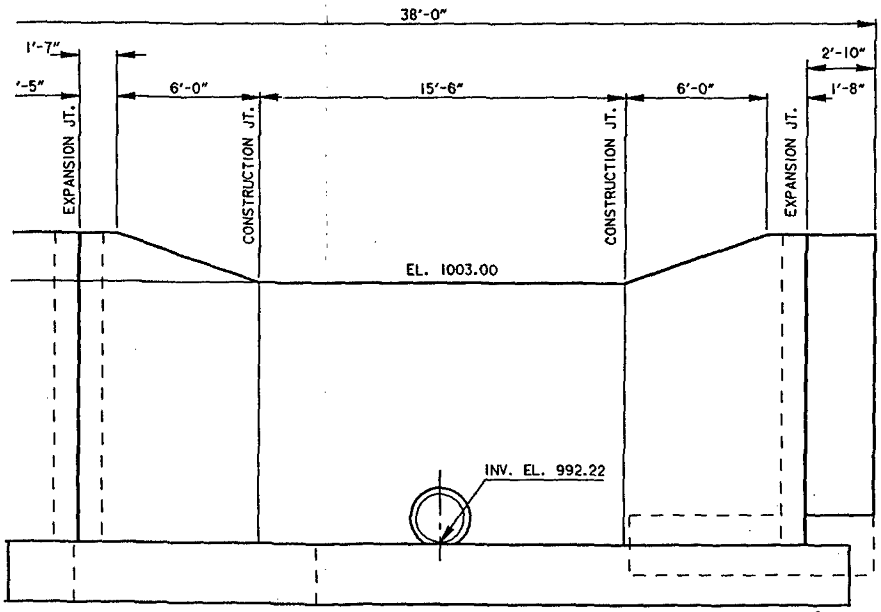
AE APPROVING OFFICIAL:

ED-D	DESIGNED: BGS
	CHECKED: DMT
	DRAWN: LKT
ED-GH	DESIGNED: XXX/XXX
	CHECKED: XXX/XXX
DATE: 04-22-92	

DESI
FLOOD CONTRC
ROCI
STAGI
PLAN, EL

CAD FILE NAME: ZS-ELEV.DGI
SPEC NO:





ELEVATION
WALL
SCALE: 1/4" = 1'-0"

A

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

ED-D
DESIGNED: BGS
CHECKED: DMT
DRAWN: LKT

ED-GH
DESIGNED: XXX/XXX
CHECKED: XXX/XXX

DATE: 04-22-92

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
U.S. 14 BRIDGE
PLAN, ELEVATION AND SECTIONS

CAD FILE NAME: ZS-ELEV.DGN
SPEC NO:
DRAWING NUMBER: PLATE 33
SHT 33 OF 53

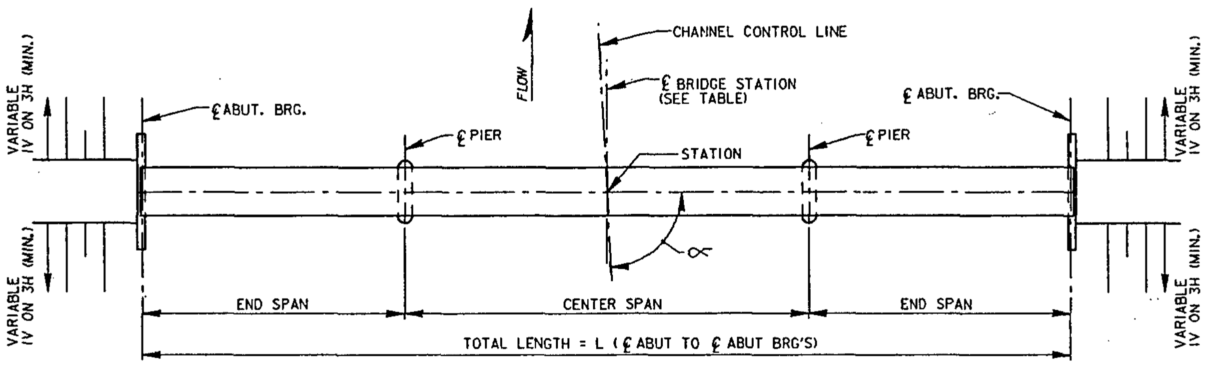
1 0 2 4 6
SCALE: 3/8" = 1'-0"

1 0 4 8
SCALE: 1/4" = 1'-0"

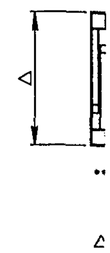
BRIDGE NO.	STATION AT CHANNEL CONTROL	LINE OFF-SET	WIDTH "W"	ANGLE ∝	TOTAL LENGTH L	END SPAN ℄ABUT-℄PIER	END SPAN CAMBER	CENTER SPAN ℄-℄PIER	CENTER CAMBER	A ELEV.	B ELEV.	C ELEV.	D ELEV.	G ELEV.	AI
1	40+15.00	0	10'-0"	90°	195'-0"	52.125' SLOPE	.05'	90.75' V.C=90'	0.3'	985.30	998.8	979.00	991.0±	1001.0±	
2	51+25.00	0	10'-0"	90°	195'-0"	52.125' SLOPE	.05'	90.75' V.C=90'	0.3'	987.30	1000.9	981.00	993.0±	1003.0±	
3	70+00.00	0	10'-0"	90°	205'-0"	33.33' SLOPE	.05'	128.33' V.C=128'	1.30'	990.8	1005.0	985.00	996.5±	1006.5±	

NOTE: DIMENSION REFERENCE IS IN FEET.
BRIDGES TO BE FABRICATED TO PRODUCE LISTED CAMBERS UNDER DL. FOR DRAINAGE.
** DIMENSIONS AS PER MANUFACTURER REQUIREMENTS.
BRIDGES TO BE CENTERED ON CHANNEL CONTROL LINE STATION.

FOOTING DEPTH TO B
ROCK CONDITIONS DU

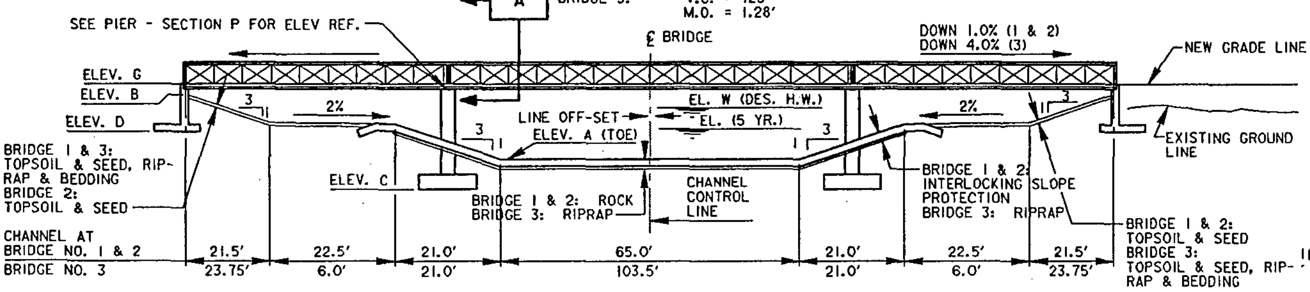


PLAN
BRIDGE
SCALE: 1" = 20'-0"



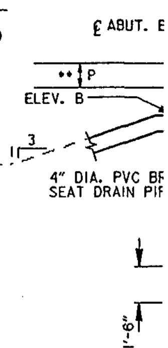
SECT
BRIDG
SCALE:

VERTICAL CURVE DATA
BRIDGE 1 & 2: V.C. = 90'
M.O. = .225
BRIDGE 3: V.C. = 128'
M.O. = 1.28'

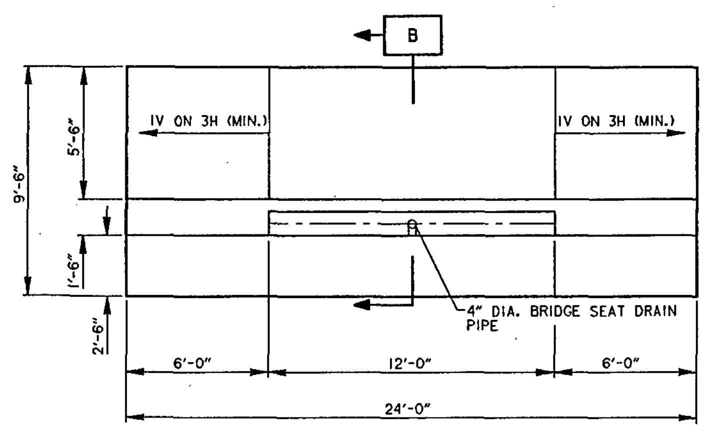


ELEVATION
BRIDGE
SCALE: 1" = 20'-0"

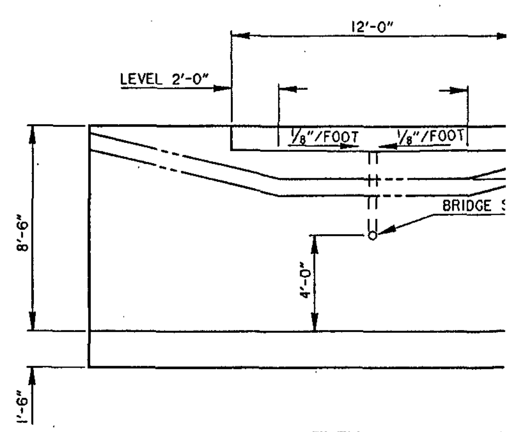
NOTE: CHANNEL CROSS-SECTIONS VARY AT EACH BRIDGE



SECTION
ABUTMENT
SCALE: 1/4"=1



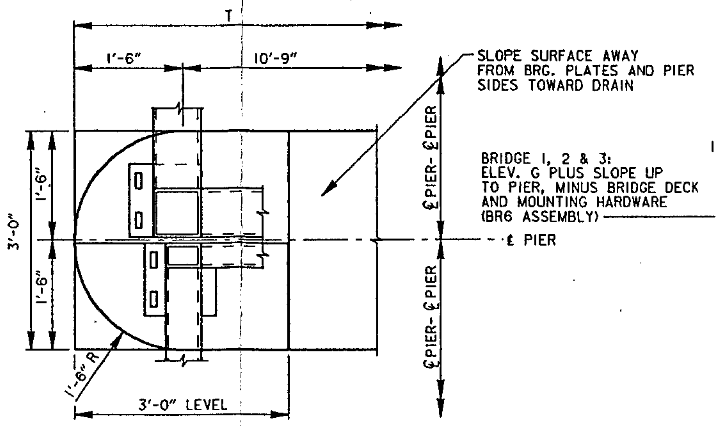
PLAN
ABUTMENT
SCALE: 1/4" = 1'-0"



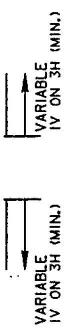
ELEVATION
ABUTMENT
SCALE: 1/4" = 1'-0"

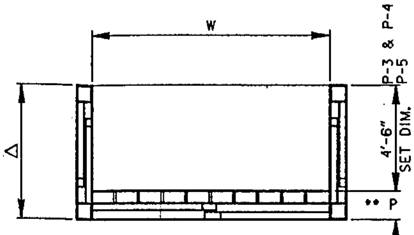
'.	C ELEV.	D ELEV.	G ELEV.	APPROACH SLAB	P DIM	R DIM	S DIM	T DIM
8	979.00	991.0±	1001.0±	1%	**	21.75'	12.0'	13.75'
9	981.00	993.0±	1003.0±	1%	**	21.75'	12.0'	13.75'
0	985.00	996.5±	1006.5±	4%	** P_E/P_C	21.75'	12.0'	13.75'

FOOTING DEPTH TO BE ADJUSTED FOR ROCK CONDITIONS DURING EXCAVATION IN FIELD.



DETAIL T
ANCHOR BOLT LAYOUT
SCALE: 3/4"=1'-0"

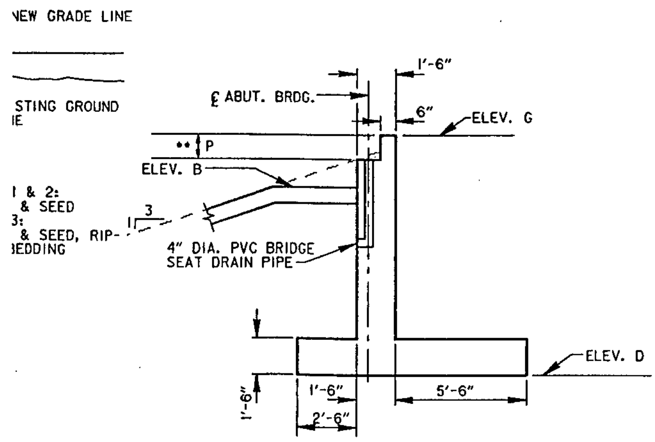




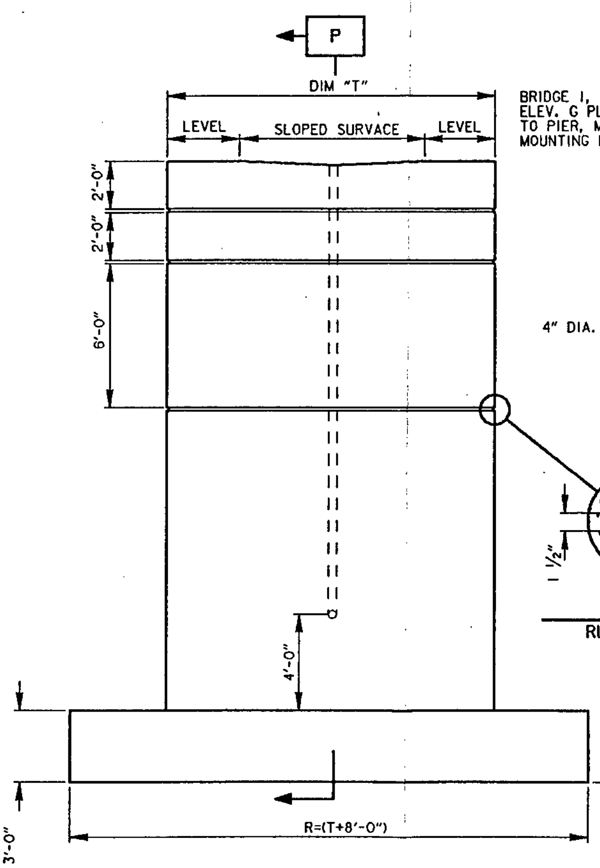
**DIMENSION AS PER MANUFACTURER'S REQUIREMENT. AT ABUTMENTS: BOTTOM OF TRUSS PLUS BEARING ℞'S.

ΔNOTE: TRUSS HEIGHT H VARIES FOR PEDESTRIAN BRIDGE 3 END AND CENTER SPANS. REQUIRING A PIER CAP STEP BASED ON P_E /P_C DIMENSIONS (**).

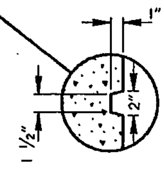
SECTION A
BRIDGE
SCALE: 1/4"=1'-0"



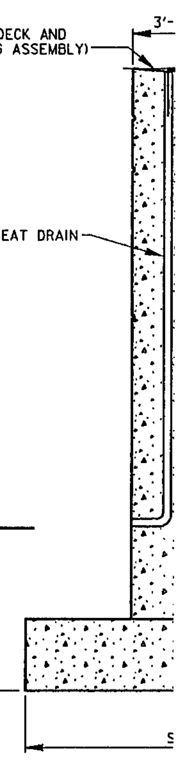
SECTION B
ABUTMENT
SCALE: 1/4"=1'-0"



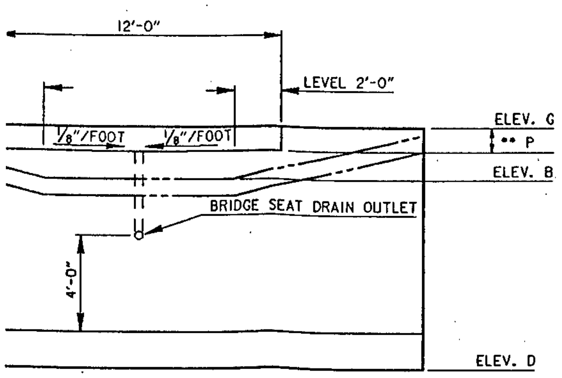
ELEVATION
PIER
SCALE: 1/4" = 1'-0"



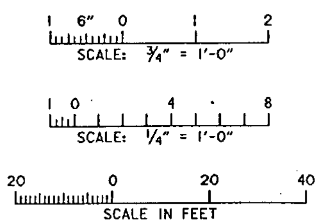
DETAIL
RUSTICATION
NO SCALE



SECTION
PIER BRIDGE 1, 2 &
SCALE: 1/4"=1'-0"



ELEVATION
ABUTMENT
SCALE: 1/4" = 1'-0"



SYMBOL	DESCRIPTION

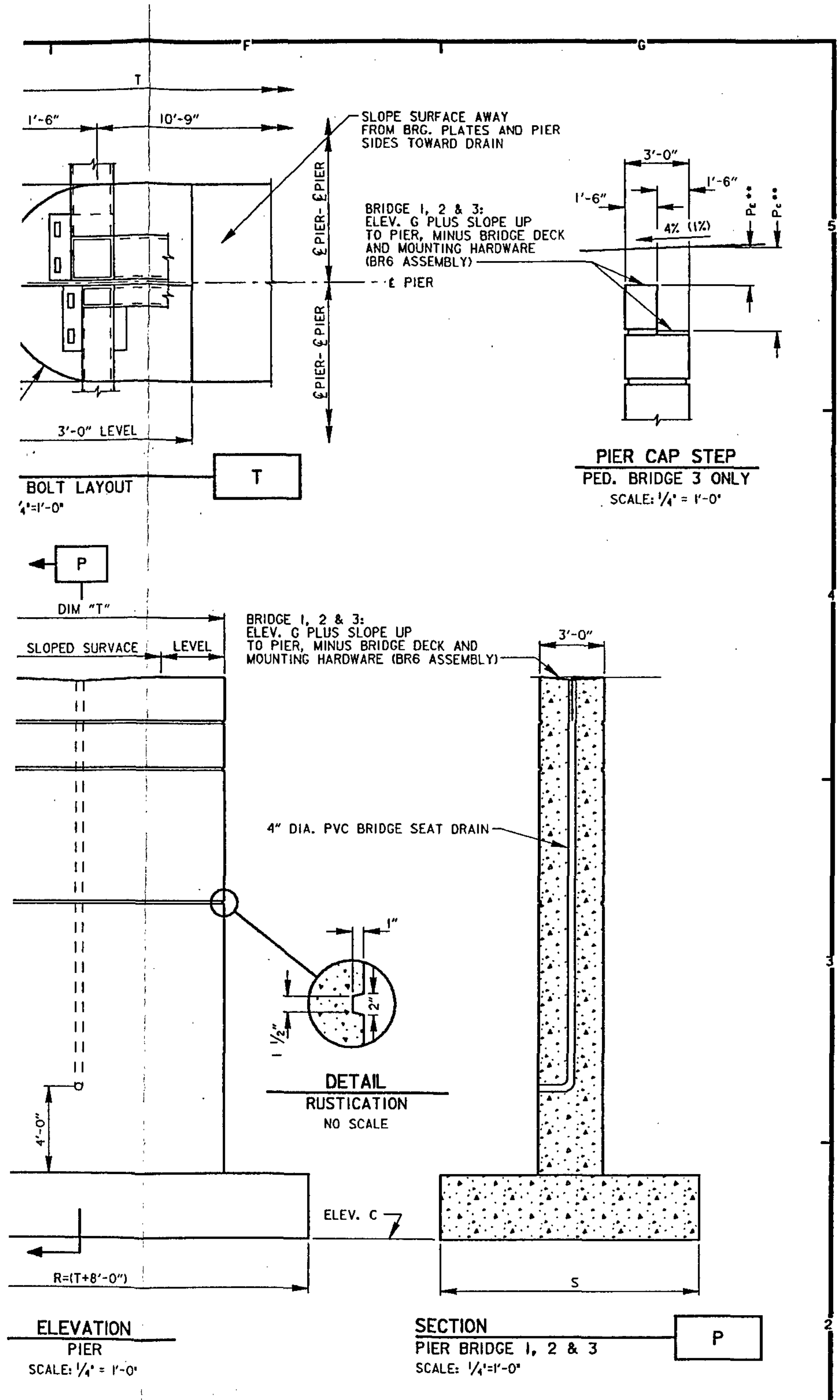
DE
ST. P

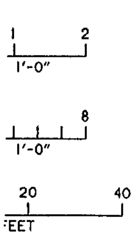
AE APPROVING OFFICIAL:

DESIGN MEM
FLOOD CONTROL - SC
ROCHESTE
STAGE 4 -
BRIDGES
PLAN AN

ED-D	DESIGNED: BGS
	CHECKED: DMT
	DRAWN: KAH/LKT
ED-GH	DESIGNED: XXX/XXX
	CHECKED: XXX/XXX
DATE: 04-21-92	

CAD FILE NAME: ROCHI-1.DGN | DR
SPEC NO:





SYMBOL	DESCRIPTION	DATE	APPROVAL

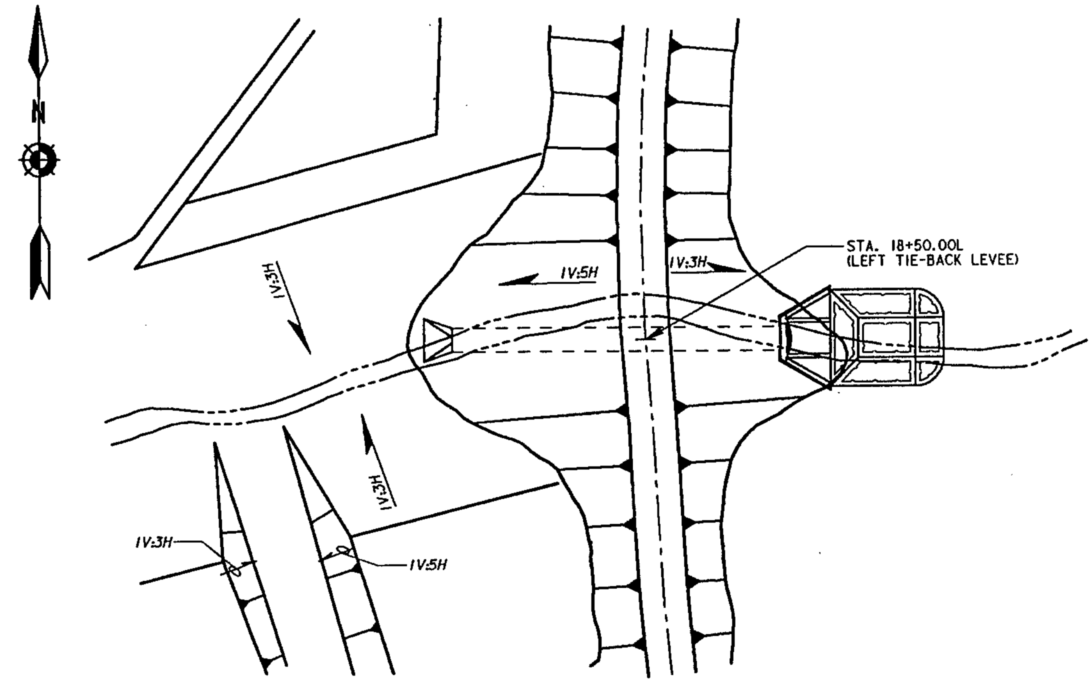
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

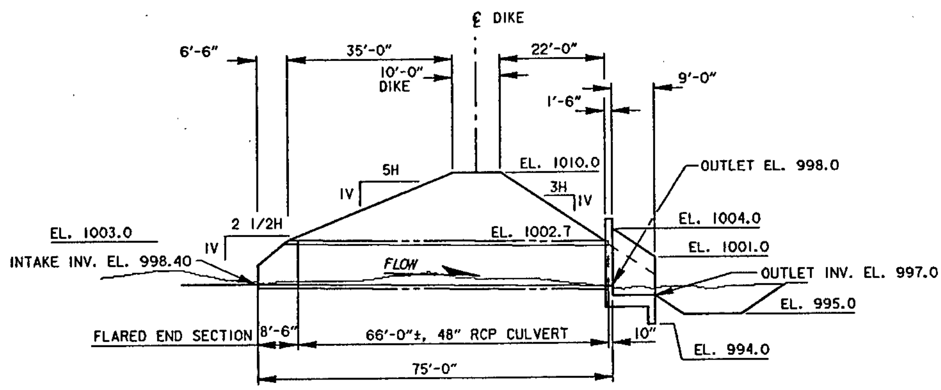
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
BRIDGES 1, 2 & 3
PLAN AND SECTIONS

ED-D	DESIGNED:	BGS
ED-D	CHECKED:	DMT
ED-D	DRAWN:	KAH/LKT
ED-GH	DESIGNED:	XXX/XXX
ED-GH	CHECKED:	XXX/XXX

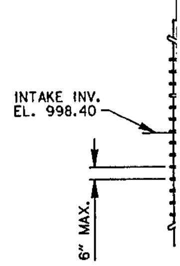
DATE: 04-21-92
CAD FILE NAME: ROCH1-1.DGN
SPEC NO:
DRAWING NUMBER: PLATE 34
SHT 34 OF 53

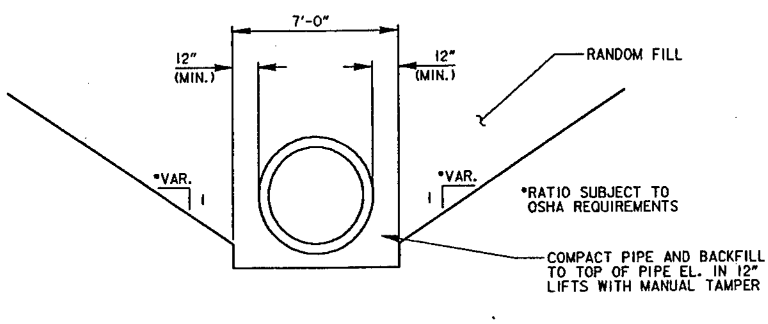


PLAN
48" DIA. RCP CULVERT WITH FLAP GATE
SCALE: 1" = 20'-0"

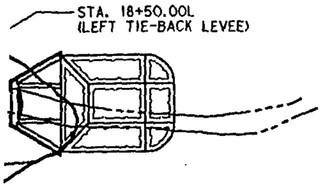


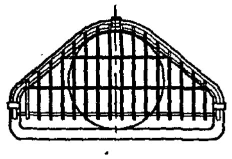
SECTION
PIPE ℄
SCALE: VERTICAL: 1"=10'-0"
HORIZONTAL: 1"=20'-0"



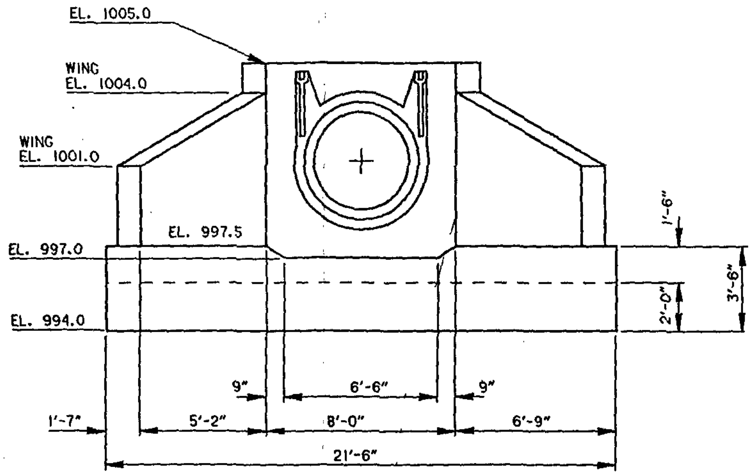


SECTION
PIPE AND BEDDING
SCALE: 1/4" = 1'-0"





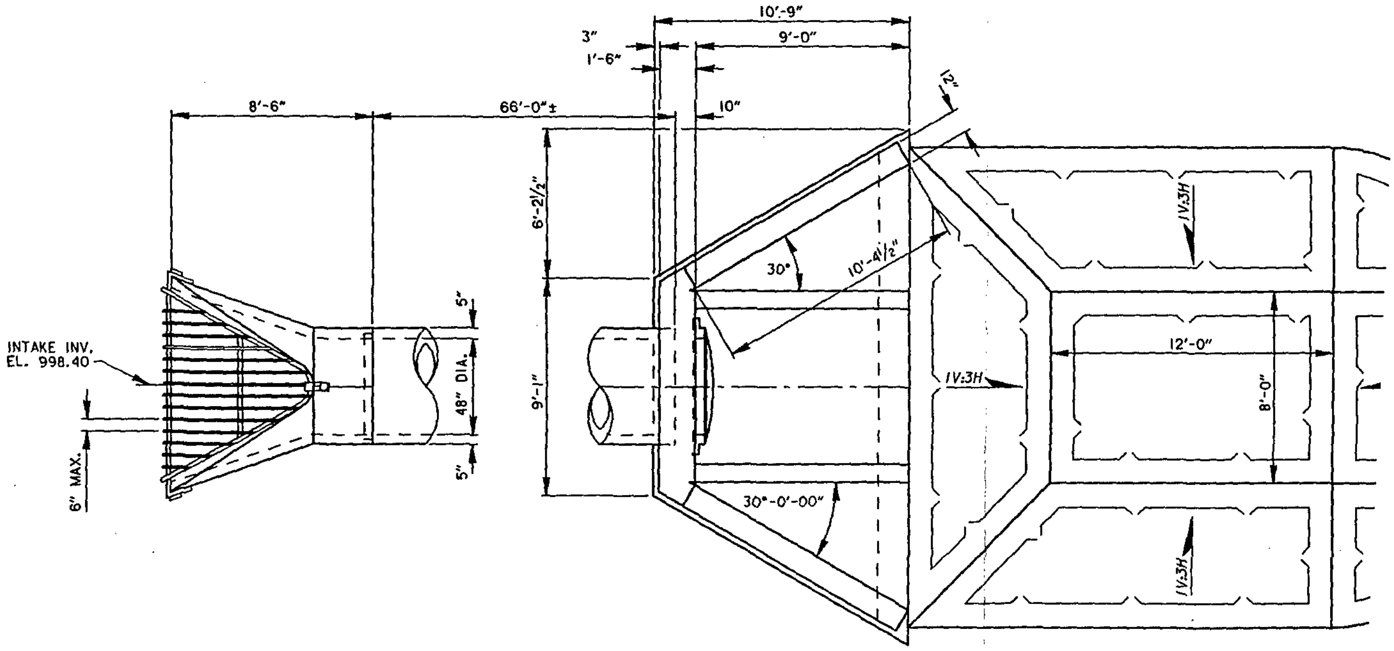
ELEVATION
INTAKE
SCALE: 1/4" = 1'-0"



ELEVATION
OUTLET
SCALE: 1/4" = 1'-0"

GATE

.0



LAYOUT
INTAKE & OUTLET ENDS
SCALE: 1/4" = 1'-0"

FILL
12"
PER

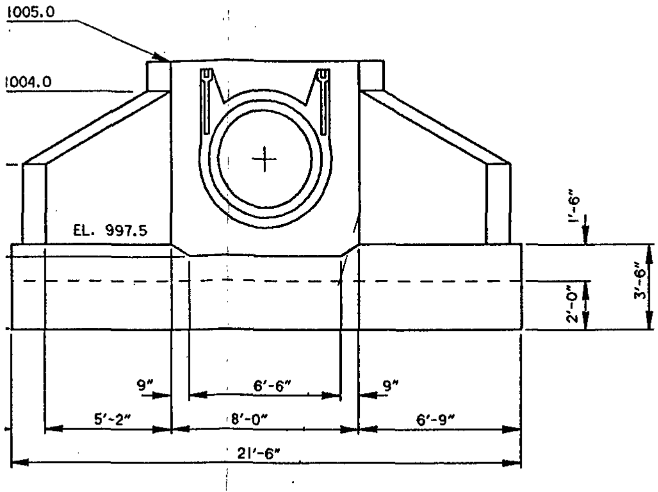
20 0 20 40
SCALE IN FEET

10 0 10 20
SCALE IN FEET

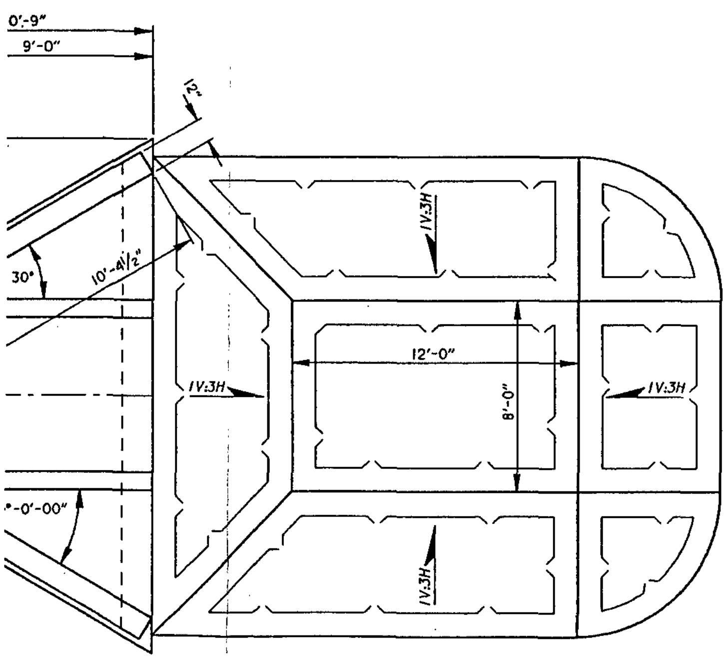
1 0 4 8
SCALE: 1/4" = 1'-0"

SYMBOL	DESC

AE APPROVING OFFICIAL:	FLOOD
ED-D DESIGNED: BGS	RCP CU
ED-D CHECKED: DMT	PL
ED-D DRAWN: KAH/LKT	
ED-GH DESIGNED: XXX/XXX	
ED-GH CHECKED: XXX/XXX	CAD FILE NAME: RC
DATE: 04-21-92	SPEC NO:



ELEVATION
OUTLET
SCALE: 1/4" = 1'-0"



20 40
E IN FEET

10 20
E IN FEET

4 8
1/4" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

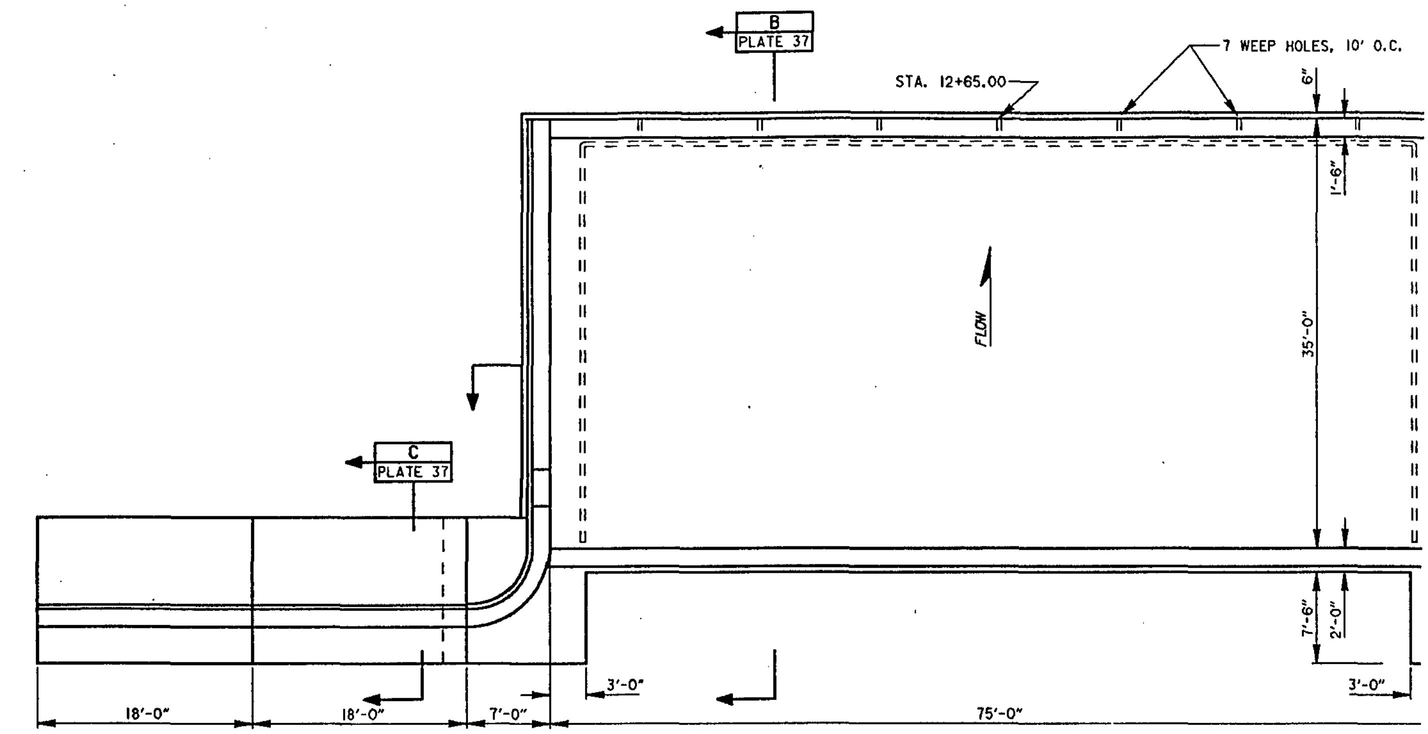
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

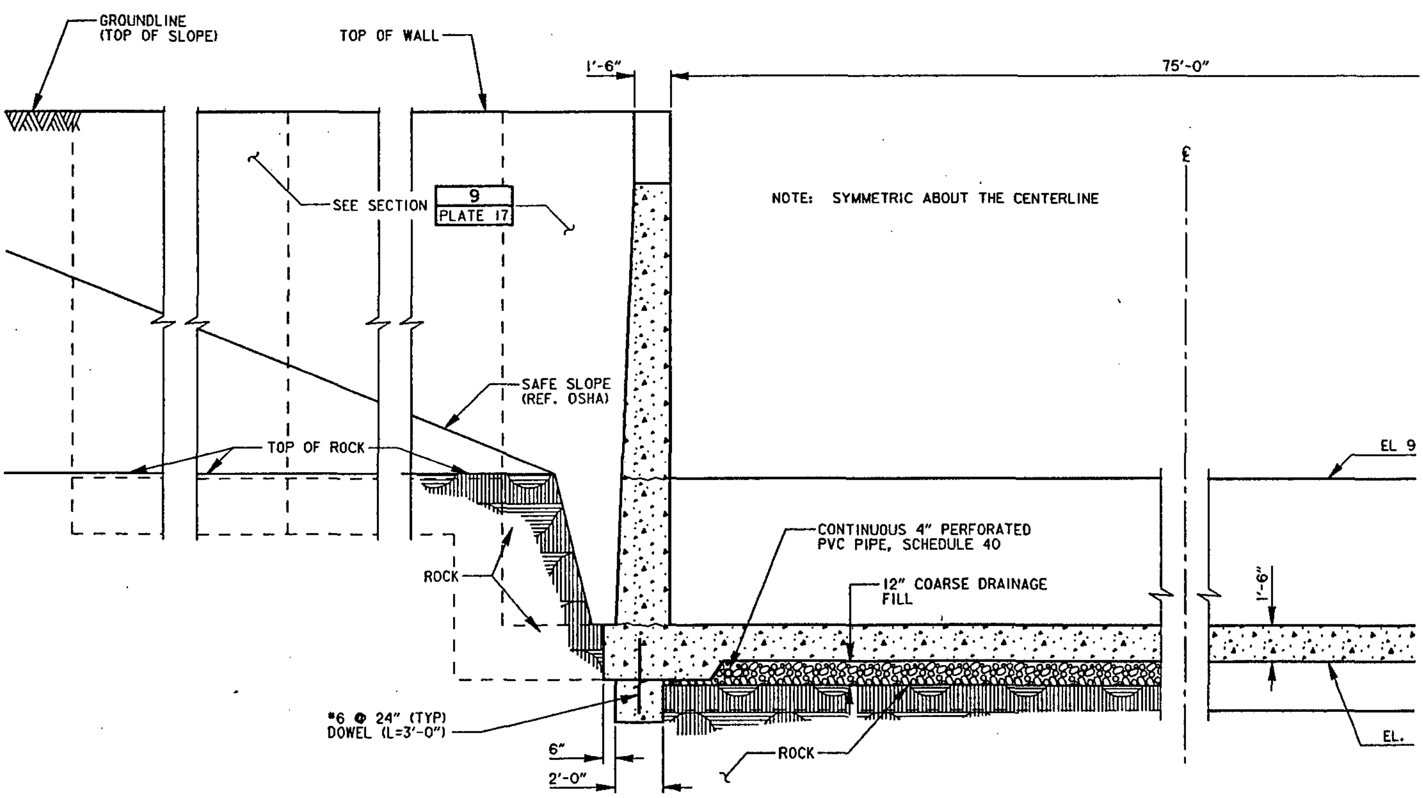
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
RCP CULVERT WITH FLAP GATE, STA. 18+50L
PLAN, ELEVATIONS, AND SECTIONS

ED-D	DESIGNED:	BGS
ED-D	CHECKED:	DMT
ED-D	DRAWN:	KAH/LKT
ED-GH	DESIGNED:	XXX/XXX
ED-GH	CHECKED:	XXX/XXX

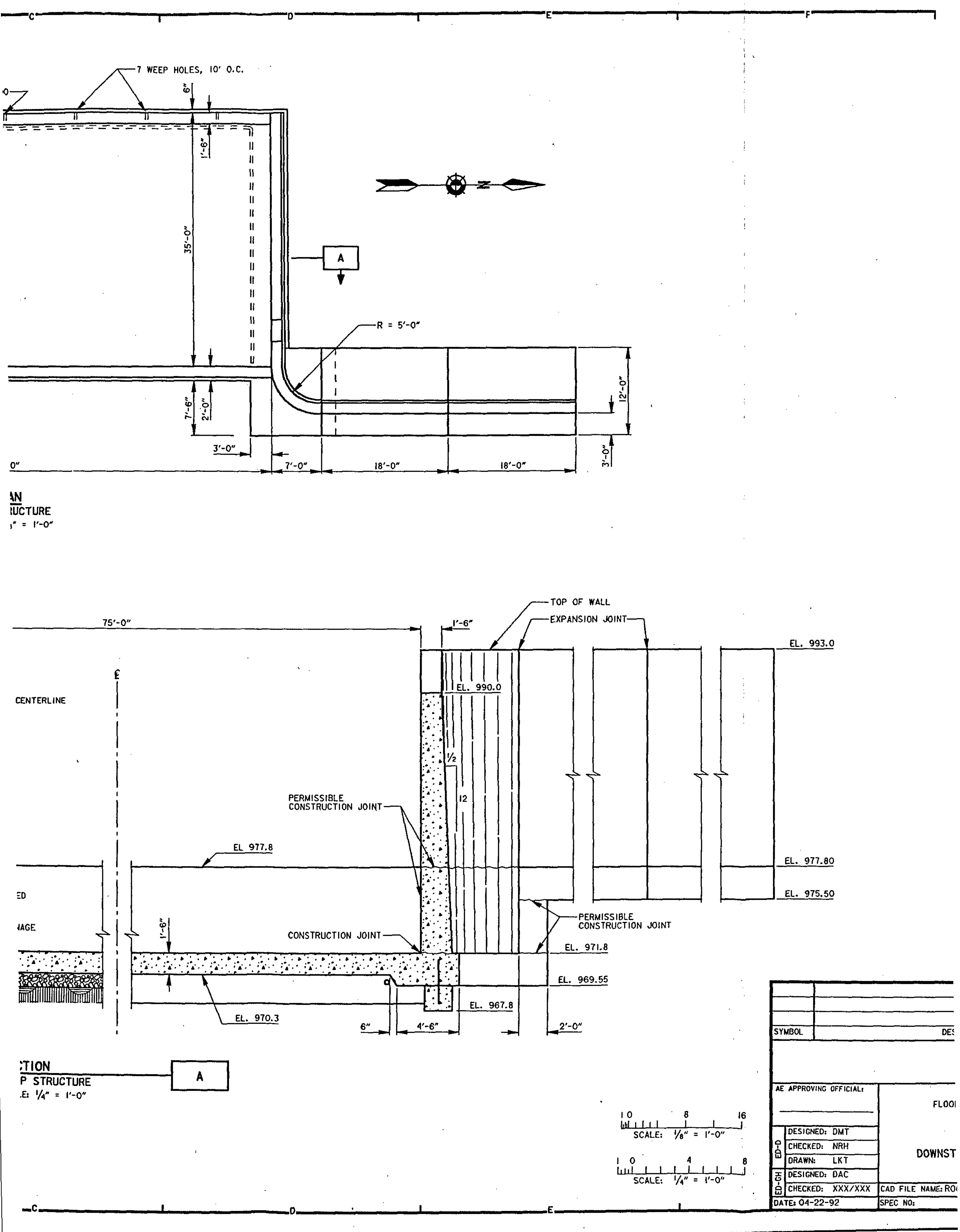
DATE: 04-21-92
CAD FILE NAME: ROCH1-2.DGN
SPEC NO:
DRAWING NUMBER:
PLATE 35
SHT 35 OF 53

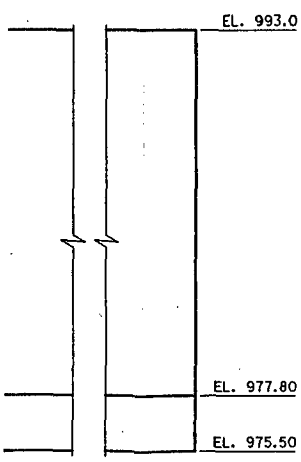


PLAN
DROP STRUCTURE
SCALE: 1/8" = 1'-0"



SECTION A
DROP STRUCTURE
SCALE: 1/4" = 1'-0"


7 WEEP HOLES, 10' O.C.
6"
1'-6"
35'-0"
A
R = 5'-0"
12'-0"
7'-6"
2'-0"
3'-0"
3'-0"
0"
7'-0"
18'-0"
18'-0"
AN
UCTURE
" = 1'-0"
TOP OF WALL
EXPANSION JOINT
75'-0"
1'-6"
EL. 993.0
EL. 990.0
CENTERLINE
1/2
12
PERMISSIBLE CONSTRUCTION JOINT
EL 977.8
EL. 977.80
EL. 975.50
ED
IAGE
PERMISSIBLE CONSTRUCTION JOINT
1'-6"
CONSTRUCTION JOINT
EL. 971.8
EL. 969.55
EL. 967.8
EL. 970.3
6"
4'-6"
2'-0"
TION
P STRUCTURE
E: 1/4" = 1'-0"
A
SYMBOL
DES
AE APPROVING OFFICIAL:
FLOO
DESIGNED: DMT
CHECKED: NRH
DRAWN: LKT
DESIGNED: DAC
CHECKED: XXX/XXX
DATE: 04-22-92
ED-D
ED-GH
DOWNST
CAD FILE NAME: RO
SPEC NO:
10 8 16
SCALE: 1/8" = 1'-0"
1 0 4 8
SCALE: 1/4" = 1'-0"
C
D
E
F



NT

8 16
: 1/8" = 1'-0"

4 8
: 1/4" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

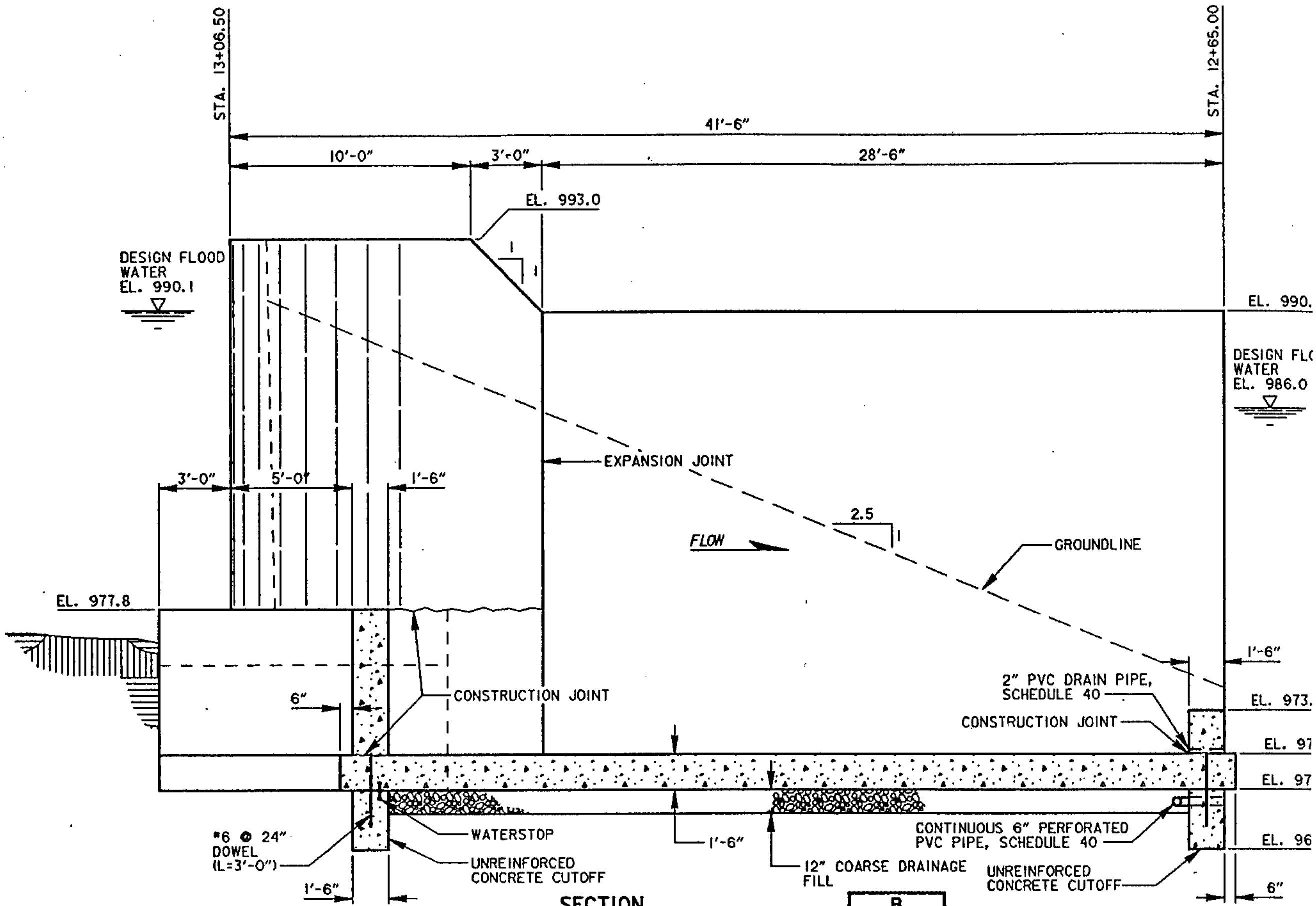
AE APPROVING OFFICIAL:

ED-D	DESIGNED:	DMT
ED-D	CHECKED:	NRH
ED-D	DRAWN:	LKT
ED-GH	DESIGNED:	DAC
ED-GH	CHECKED:	XXX/XXX

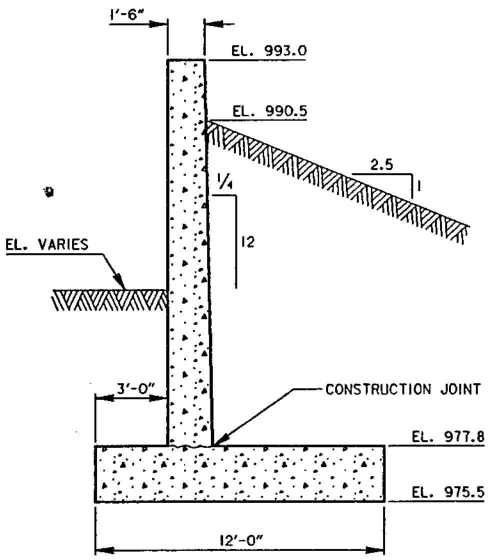
DATE: 04-22-92

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
DOWNSTREAM DROP STRUCTURE & WINGWALLS
PLAN AND SECTION

CAD FILE NAME: ROCH4-1.DGN
SPEC NO:
DRAWING NUMBER: PLATE 36
SHT 36 OF 53

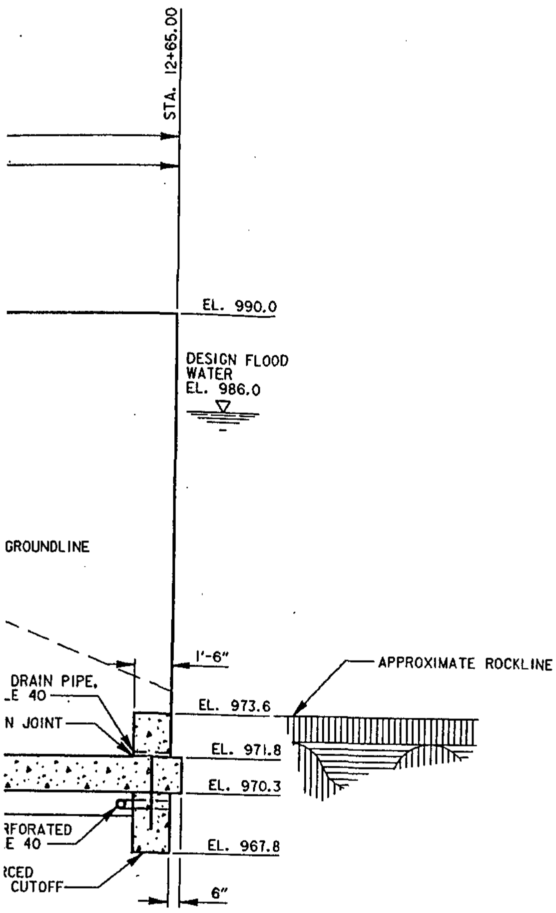


SECTION | **B**
DROP STRUCTURE | PLATE 36
SCALE: 1/4" = 1'-0"



SECTION | **C**
U/S WINGWALL | PLATE 36
SCALE: 1/4" = 1'-0"

D E F



SYMBOL	DESCRIPTION

DEPA
ST. PAUL

AE APPROVING OFFICIAL:

ED-D	DESIGNED:	DMT
	CHECKED:	NRH
	DRAWN:	LKT
ED-GH	DESIGNED:	XXX/XXX
	CHECKED:	XXX/XXX
DATE: 04-20-92		

DESIGN MEMOR
FLOOD CONTROL - SOUT
ROCHESTER,
STAGE 4 - E
DOWNSTREAM DROP STR
SECTI

CAD FILE NAME: ROCH4-2.DGN | DRAWI
SPEC NO:

D E

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
DOWNSTREAM DROP STRUCTURE & WINGWALLS
SECTIONS

ED-D	DESIGNED:	DMT
ED-D	CHECKED:	NRH
ED-D	DRAWN:	LKT
ED-GH	DESIGNED:	XXX/XXX
ED-GH	CHECKED:	XXX/XXX

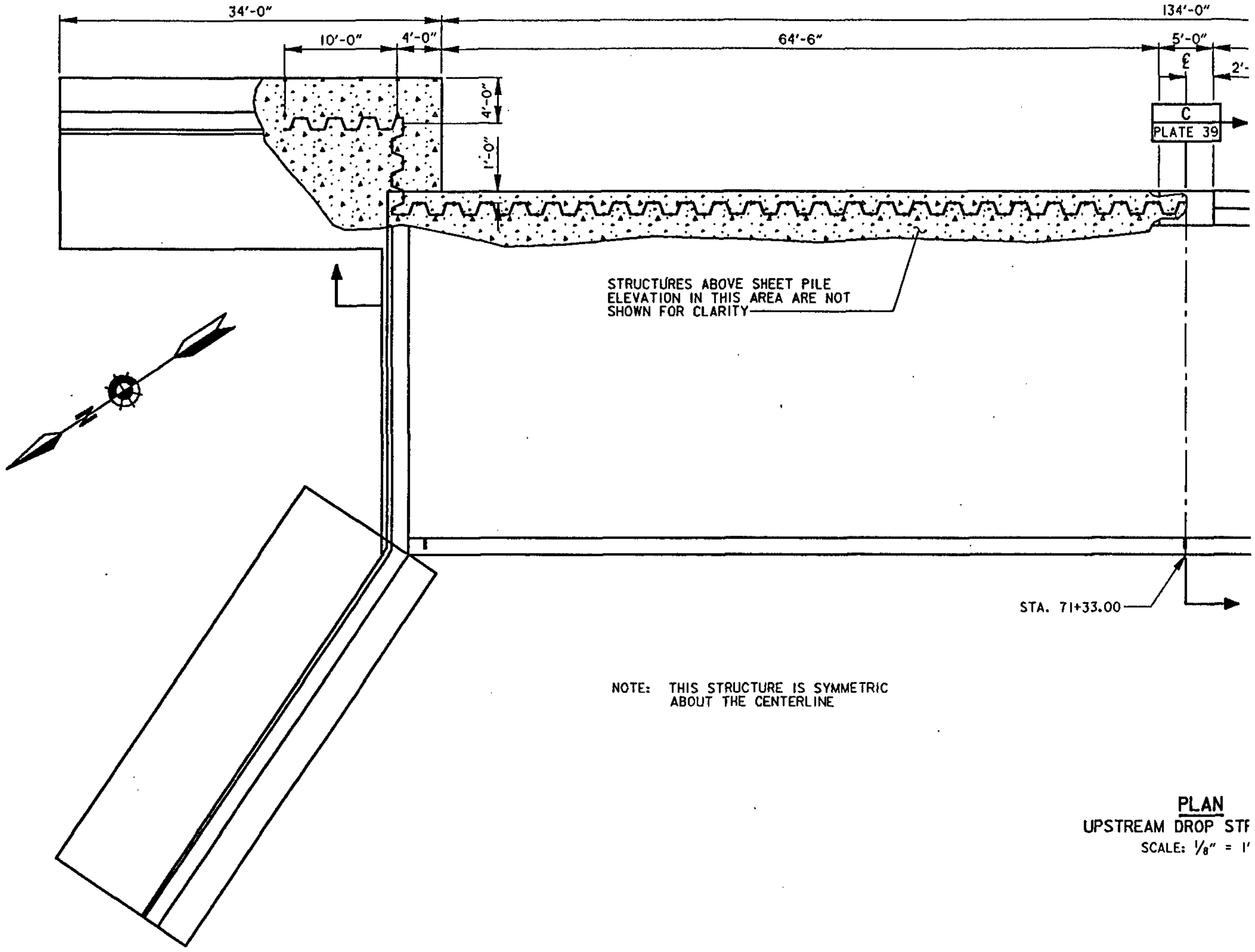
DATE: 04-20-92

CAD FILE NAME: ROCH4-2.DGN

SPEC NO:

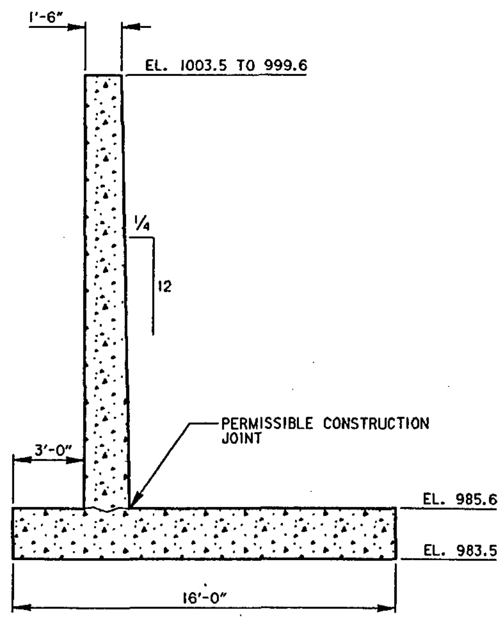
DRAWING NUMBER: PLATE 37

SHT 37 OF 53

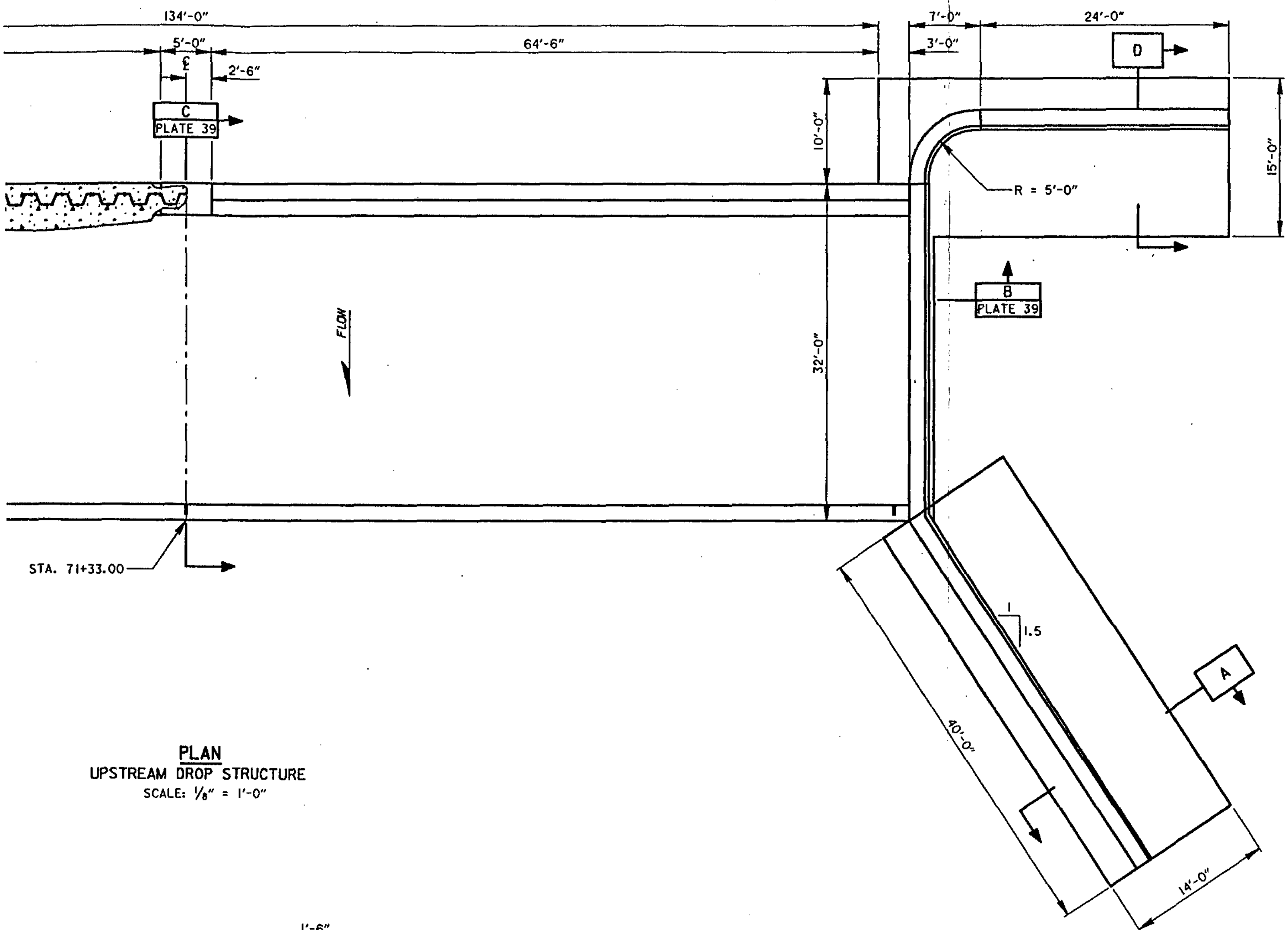


NOTE: THIS STRUCTURE IS SYMMETRIC ABOUT THE CENTERLINE

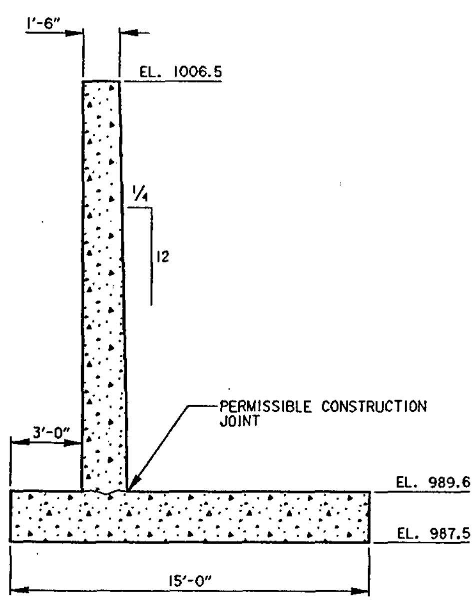
PLAN
UPSTREAM DROP STI
SCALE: 1/8" = 1'



SECTION A
DOWNSTREAM WING WALL
SCALE: 1/4" = 1'-0"



PLAN
UPSTREAM DROP STRUCTURE
SCALE: 1/8" = 1'-0"



SECTION
UPSTREAM WING WALL
SCALE: 1/4" = 1'-0"

D

1 0 4 8
SCALE: 1/4" = 1'-0"

1 0 8 16
SCALE: 1/8" = 1'-0"

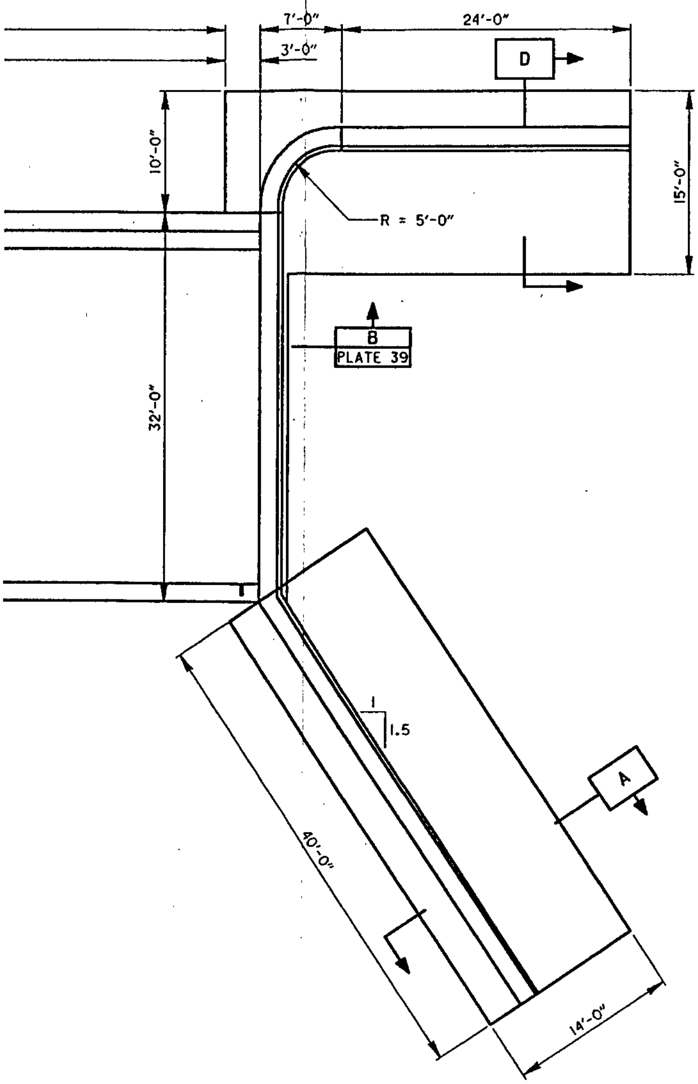
SYMBOL	DESCRIPTION

AE APPROVING OFFICIAL:

ED-D	DESIGNED: DMT/BGS
	CHECKED: NRH
	DRAWN: LKT
ED-GH	DESIGNED: DAC
	CHECKED: XXX/XXX
DATE: 04-22-92	

DESIGN
FLOOD CONTROL
ROCHES
STAGE
UPSTREAM DROP
PLAN

CAD FILE NAME: ROCH4-4.DGN
SPEC NO:



SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

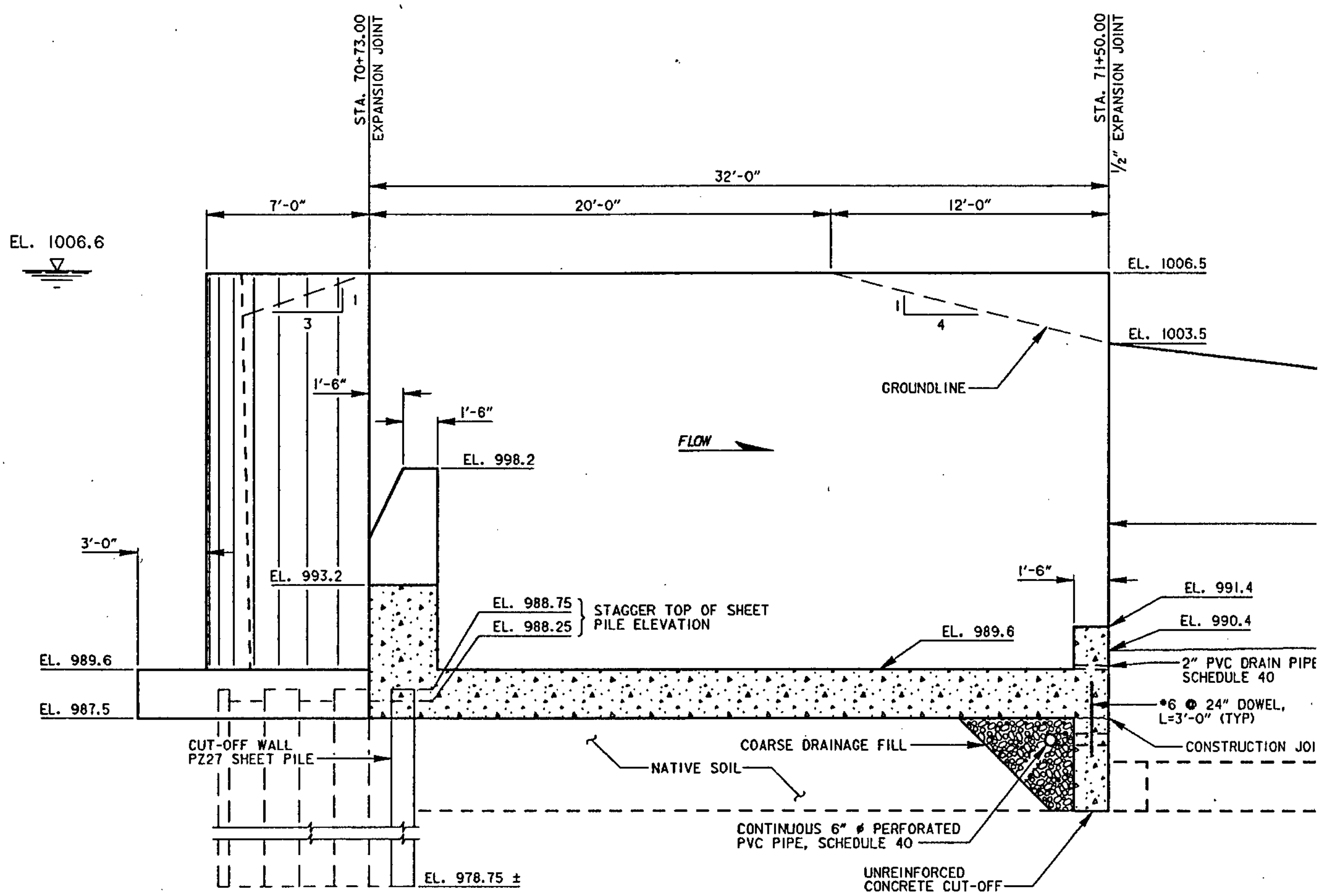
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
UPSTREAM DROP STRUCTURE & WING WALLS
PLAN AND SECTIONS

ED-D	DESIGNED:	DMT/BGS
	CHECKED:	NRH
	DRAWN:	LKT
ED-GH	DESIGNED:	DAC
	CHECKED:	XXX/XXX

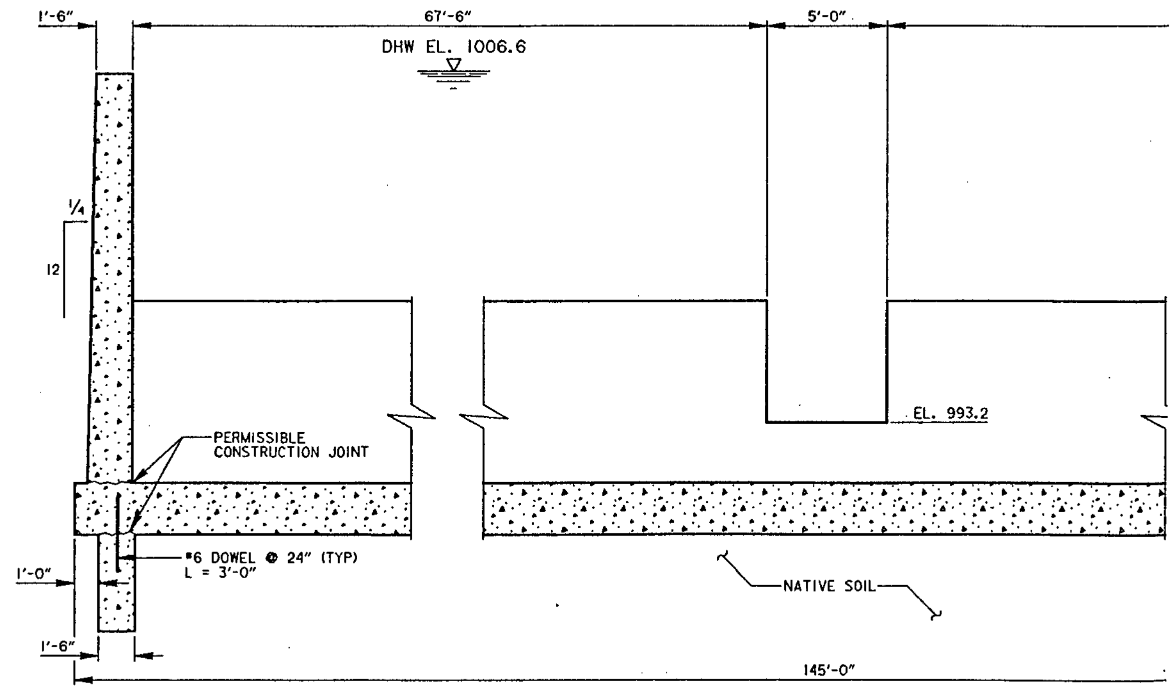
DATE: 04-22-92
CAD FILE NAME: ROCH4-4.DGN
SPEC NO:
DRAWING NUMBER: PLATE 38
SHT 38 OF 53

0 4 8
SCALE: 1/4" = 1'-0"

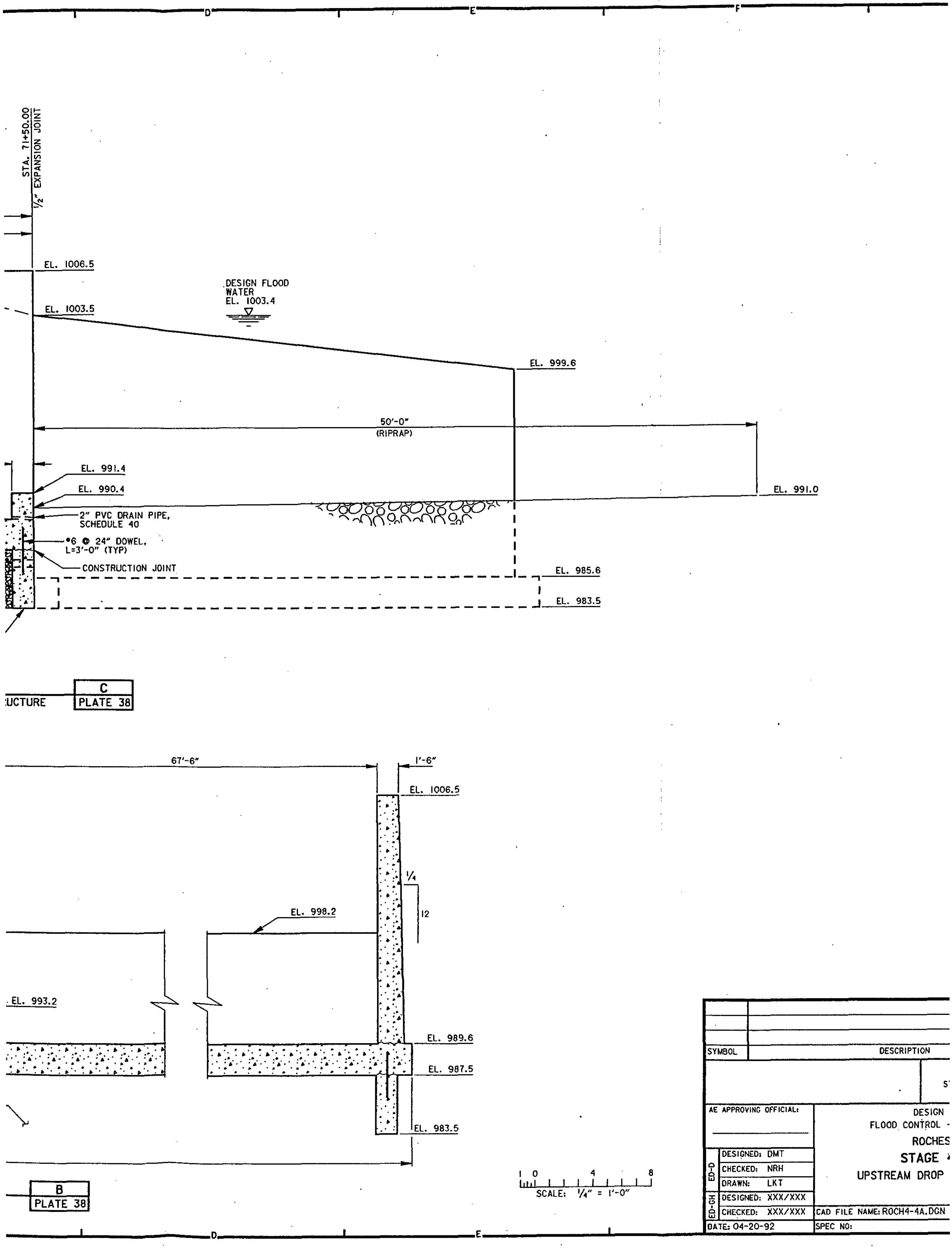
0 8 16
SCALE: 1/8" = 1'-0"



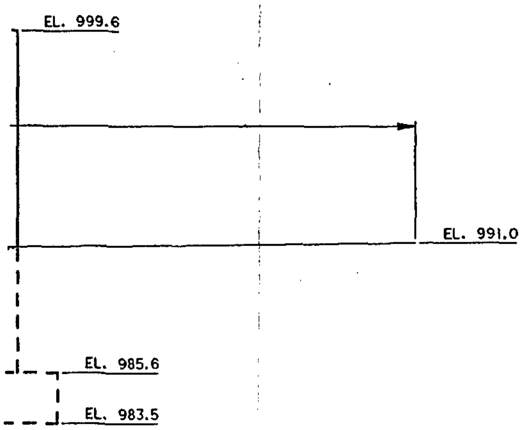
SECTION | **C**
USTREAM DROP STRUCTURE | PLATE 38
SCALE: 1/4" = 1'-0"



SECTION | **B**
DROP WALL | PLATE 38
SCALE: 1/4" = 1'-0"



D
E
F
STA. 71+50.00
1/2" EXPANSION JOINT
EL. 1006.5
DESIGN FLOOD
WATER
EL. 1003.4
EL. 1003.5
EL. 999.6
50'-0"
(RIPRAP)
EL. 991.4
EL. 990.4
2" PVC DRAIN PIPE,
SCHEDULE 40
#6 @ 24" DOWEL,
L=3'-0" (TYP)
CONSTRUCTION JOINT
EL. 991.0
EL. 985.6
EL. 983.5
:UCTURE
C
PLATE 38
67'-6"
1'-6"
EL. 1006.5
1/4
12
EL. 998.2
EL. 993.2
EL. 989.6
EL. 987.5
EL. 983.5
B
PLATE 38
0 4 8
SCALE: 1/4" = 1'-0"
SYMBOL
DESCRIPTION
AE APPROVING OFFICIAL:
DESIGNED: DMT
CHECKED: NRH
DRAWN: LKT
ED-D
DESIGNED: XXX/XXX
CHECKED: XXX/XXX
ED-GH
DATE: 04-20-92
DESIGN
FLOOD CONTROL -
ROCHES
STAGE
UPSTREAM DROP
CAD FILE NAME: ROCH4-4A.DGN
SPEC NO:



0 4 8

SCALE: 1/4" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

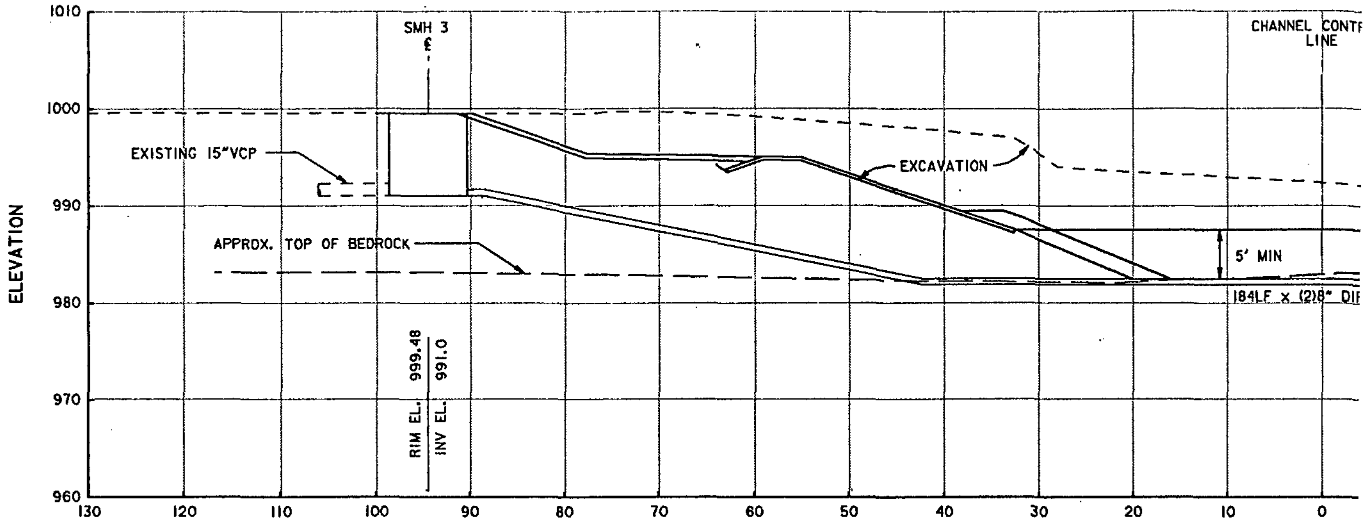
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

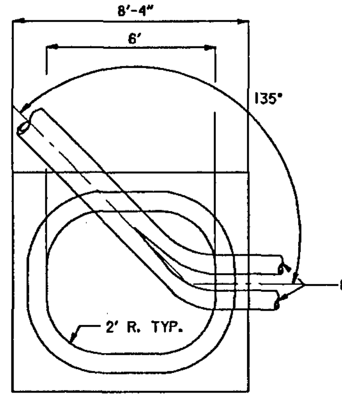
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
UPSTREAM DROP STRUCTURE & WING WALLS
SECTIONS

ED-D: DESIGNED: DMT; CHECKED: NRH; DRAWN: LKT
ED-GH: DESIGNED: XXX/XXX; CHECKED: XXX/XXX
DATE: 04-20-92

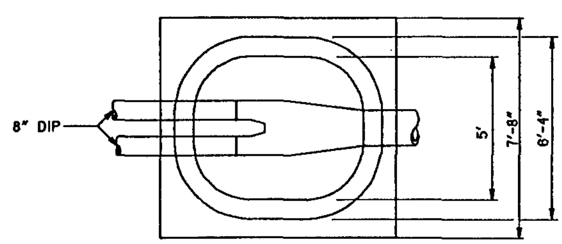
CAD FILE NAME: ROCH4-4A.DGN
SPEC NO:
DRAWING NUMBER: PLATE 39
SHT 39 OF 53



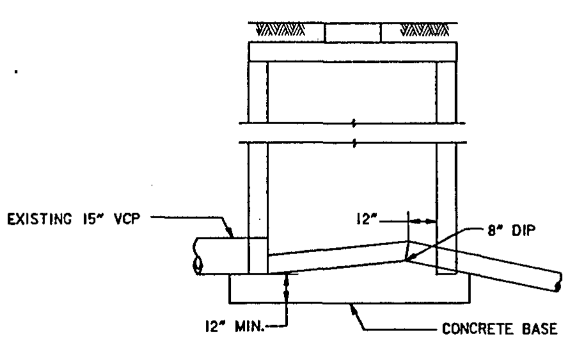
PROFILE
SANITARY SEWER
SCALE: 1"=10'-0"



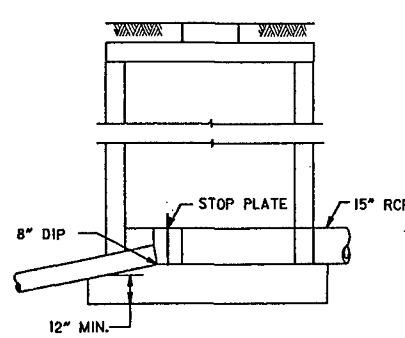
PLAN



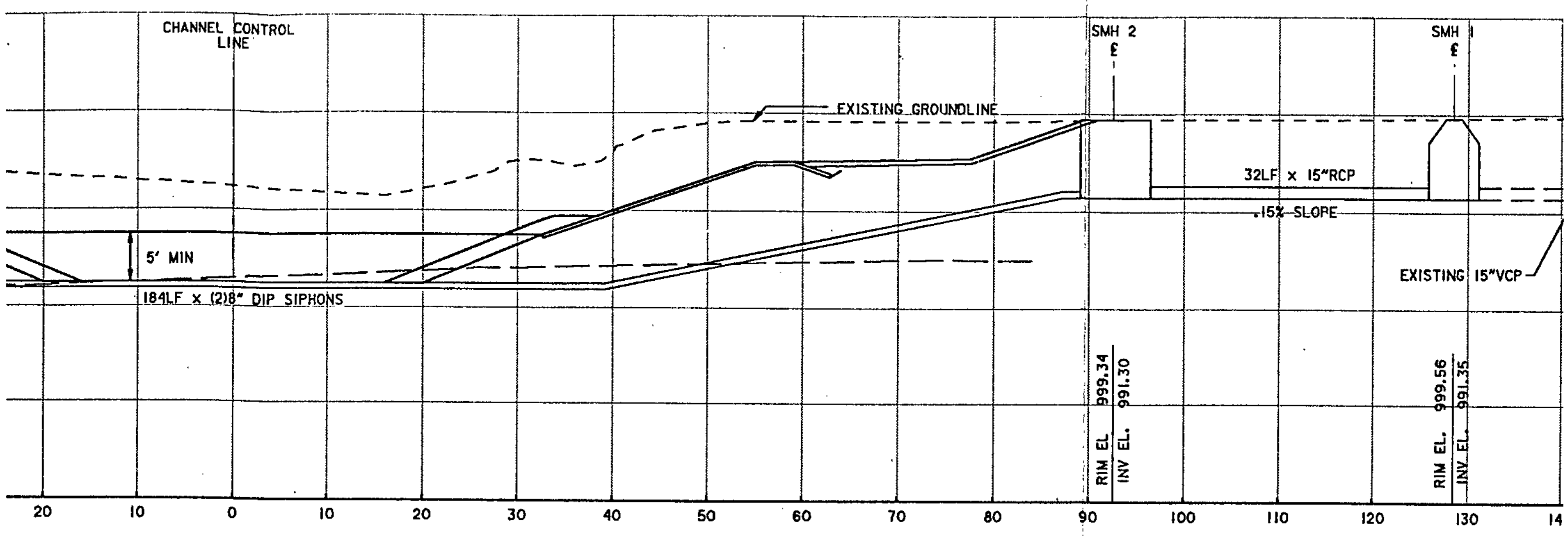
PLAN



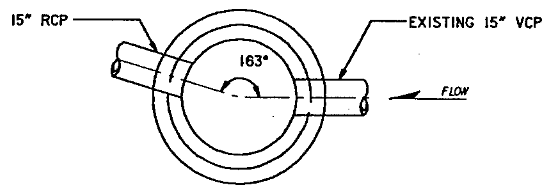
ELEVATION
SMH 3



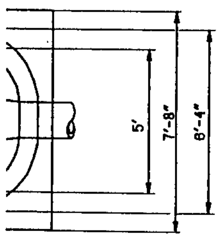
ELEVATION
SMH 2

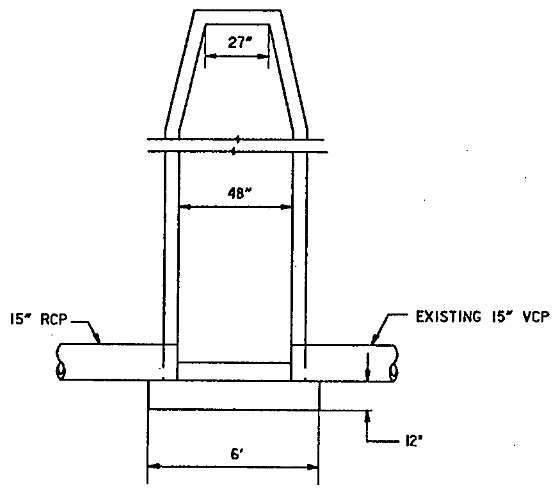


PROFILE
SANITARY SEWER SIPHON
SCALE: 1"=10'-0"

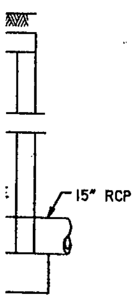


PLAN





ELEVATION
SMH 1



N

SYMBOL	DESCRIPTION

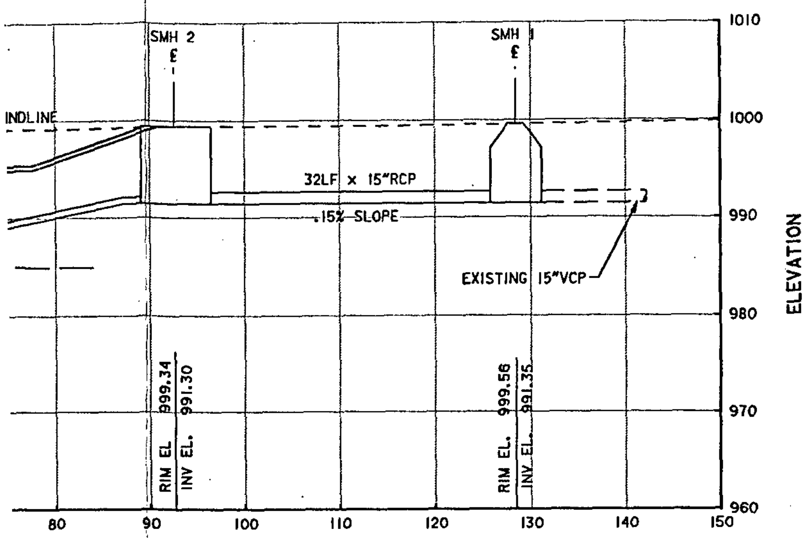
DE
ST. PA

AE APPROVING OFFICIAL:

DESIGN MEMO
FLOOD CONTROL - SOU
ROCHESTER
STAGE 4-
SANITARY S
PROFILE A
STATIO

ED-D DESIGNED: EPP
CHECKED: GVF
DRAWN: EPP
ED-GH DESIGNED:
CHECKED:
DATE: MAY 92

CAD FILE NAME: r4sansl.dgn
DRA
SPEC NO:



SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

STAGE 4-BEAR CREEK
SANITARY SEWER SIPHON
PROFILE AND DETAILS
STATION 51+80

ED-D: DESIGNED: EPP; CHECKED: GVF; DRAWN: EPP
ED-CH: DESIGNED: ; CHECKED:
DATE: MAY 92

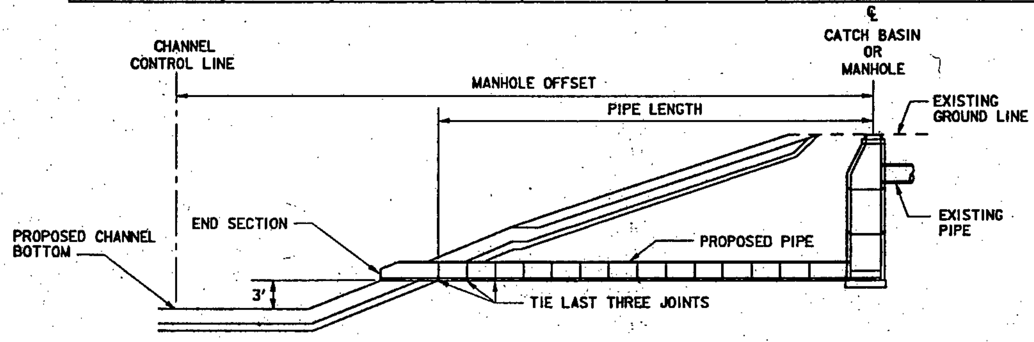
CAD FILE NAME: r4sonsi.dgn
SPEC NO:

DRAWING NUMBER: PLATE 40

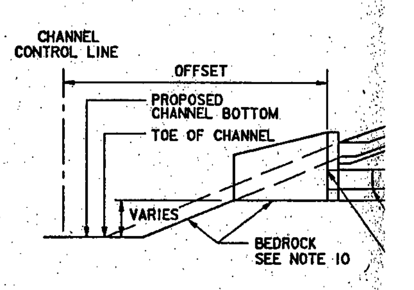
SHT 40 OF 53

STORM SEWER SCHEDULE

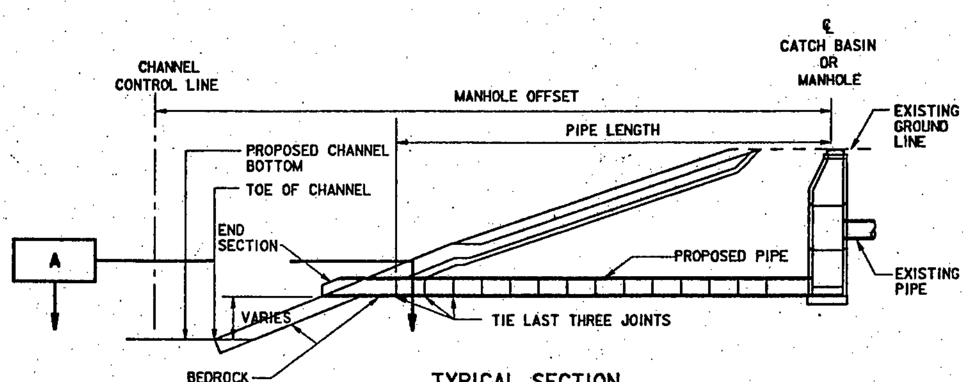
CATCH BASIN OR MANHOLE NO.	PROFILE SHEET NO.	LOCATION (SEE NOTE 8) STATION	OFFSET	ANGLE SEE NOTE 7	MH/CB DEPTH & TYPE	TOP OF CASTING	CASTING TYPE (SEE NOTE 4)	OUTLET ELEV.	DRAINS TO NO.	OUTLET TYPE	% GRADE	INLE INV.
MH NO. 1	•	5+83R	93′	172°	14.1 - 1	989.5	R-1659	974.4	OUTLET NO. 1	E	.0044	97
MH NO. 2	•	7+96L	100′	236.5°	13.2 - 3	990.0	R-1659	975.8	OUTLET NO. 2	A	.0036	97
•	•	•	•	180°	•	•	•	•	MH NO. 3	•	.017	98
MH NO. 3	•	10+37R	151′	186.5°	10.1 - 1	987.8	R-1659	976.7	OUTLET NO. 3	A	.0044	97
MH NO. 4	•	10+88L	98′	183.5°	13.1 - 1	990.6	R-1659	976.5	OUTLET NO. 4	A	.0044	97
MH NO. 5	•	13+96R	76′	182.5°	10.0 - 1	992.2	R-1659	981.2	OUTLET NO. 5	B	.0044	98
•	•	14+17L	59′	•	•	•	•	•	OUTLET NO. 6	C	•	
MH NO.7	•	16+95R	88′	199.5°	11.7 - 1	996.8	R-1659	984.1	OUTLET NO. 7	B	.0044	98
•	•	23+57L	51′	180°	•	•	•	•	OUTLET NO. 7A	E	•	99
MH NO. 8	•	23+78R	87′	77°	7.4 - 1	996.4	R-1659	988.0	CB NO. 8	•	.0044	98
CB NO. 8	•	24+80R	69′	282°	10.9 - 1	995.0	R-2560-D2	984.5	OUTLET NO. 8	A	.0044	98
•	•	26+90L	69′	•	•	•	•	•	OUTLET NO. 9	B	.038	98
•	•	27+74R	53′	•	•	•	•	•	OUTLET NO. 10	B	•	
•	•	30+93R	49′	•	•	•	•	•	OUTLET NO. 11	B	•	
•	•	31+15R	73′	•	•	•	•	•	OUTLET NO. 12	C	.007	99
MH NO. 13	•	39+78R	118′	170.5°	6.5 - 1	997.4	R-1659	989.9	OUTLET NO. 13	D	.0044	98
•	•	44+75R	104′	SEE NOTE 3	•	•	•	•	OUTLET NO. 14	•	.0044	99
MH NO. 15	•	45+84R	103′	164.5°	9.0 - 4	999.3	R-1659	989.3	OUTLET NO. 15	D	.0018	98
MH NO. 16	•	51+49R	106′	176°	10.1 - 3	1001.7	R-1659	990.6	OUTLET NO. 16	D	.0023	99
CB NO. 17	•	61+33R	70′	SEE NOTE 2	3.6 - 4	997.0	R-2560-E2	992.4	OUTLET NO. 17	E	.0018	99
CB NO. 18	•	62+22L	59′	SEE NOTE 2	8.8 - 1	1002.0	R-2560-D2	992.2	OUTLET NO. 18	REF. 1	.003	99
CB. NO. 19	•	62+22R	61′	SEE NOTE 2	8.7 - 1	1002.0	R-2560-D2	992.3	OUTLET NO. 19	REF. 1	.003	99
•	•	•	•	•	•	•	•	•	•	•	•	



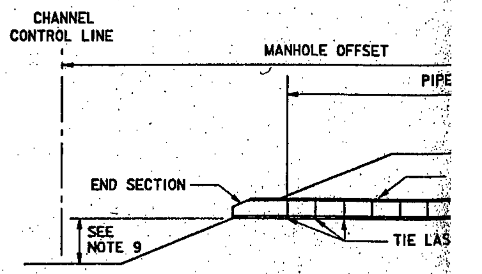
TYPICAL SECTION
STORM SEWER OUTLET
TYPE A
NOT TO SCALE



TYPICAL SECTION
STORM SEWER OUTLET
TYPE C
NOT TO SCALE



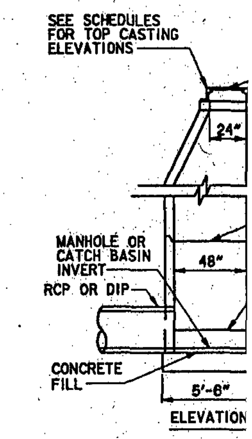
TYPICAL SECTION
STORM SEWER OUTLET
TYPE B
NOT TO SCALE



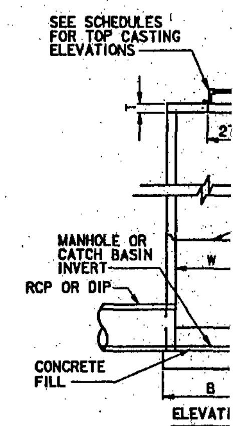
TYPICAL SECTION
STORM SEWER OUTLET
TYPE D
NOT TO SCALE

ORM SEWER SCHEDULE

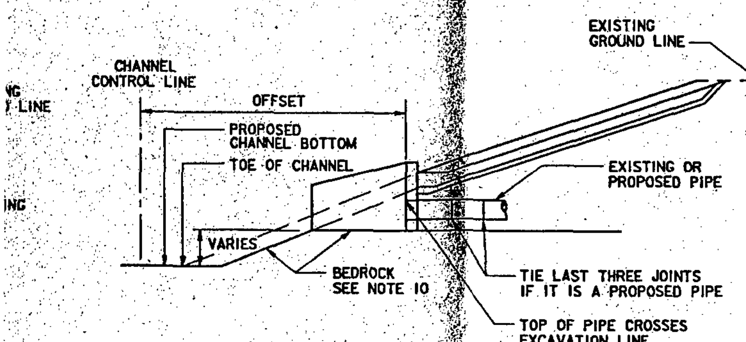
OUTLET ELEV.	DRAINS TO NO.	OUTLET TYPE	% GRADE	INLET OR INV. ELEV.	PROPOSED PIPE SIZE & TYPE	LENGTH	CLASS	END SECTION	REMARKS
974.4	OUTLET NO. 1	E	.0044	974.2	18" RCP	42'		•	CONNECT TO EXISTING 12" RCP I.E.
975.8	OUTLET NO. 2	A	.0036	975.6	21" RCP	39'		1-21" RCP	CONNECT TO EXISTING 21" RCP I.E. 981.3
•	MH NO. 3	•	.017	981.3	15" RCP	8'		•	CONNECT TO EXISTING 15" VCP I.E. 981.4
976.7	OUTLET NO. 3	A	.0044	976.2	18" RCP	98'		1-18" RCP	•
976.5	OUTLET NO. 4	A	.0044	976.3	18" RCP	45'		1-18" RCP	CONNECT TO EXISTING 18" RCP I.E. 986.2
981.2	OUTLET NO. 5	B	.0044	981.0	18" RCP	33'		1-18" RCP	CONNECT TO EXISTING 15" VCP I.E. 987.7
•	OUTLET NO. 6	C	•	•	•	•		•	PLACE HEADWALL AT EXISTING 24" RCP I.E. 984.4
984.1	OUTLET NO. 7	B	.0044	9[illegible]3.9	18" RCP	39'		1-18" RCP	CONNECT TO EXISTING 15" VCP I.E. 987.9
•	OUTLET NO. 7A	E	•	990.4	12" RCP	15"		•	CONNECT TO EXISTING 12" RCP I.E. 990.4
988.0	CB NO. 8	•	.0044	9[illegible]7.6	18" RCP	97'		•	CONNECT TO EXISTING 15" RCP I.E. 988.4
984.5	OUTLET NO. 8	A	.0044	9[illegible]4.3	18" RCP	28'		1-18 RCP	•
•	OUTLET NO. 9	B	.038	9[illegible]9.8	12" RCP	16'		1-12" RCP	CONNECT TO EXISTING 12" RCP I.E. 990.51
•	OUTLET NO. 10	B	•	•	•	•		1-12" CMP	PLACE END SECTION AT EXISTING 12" CMP I.E. 990.3
•	OUTLET NO. 11	B	•	•	•	•		21" RCP	PLACE END SECTION AT EXISTING 27" RCP
•	OUTLET NO. 12	C	.007	9[illegible]1.0	18" RCP	11'		•	CONNECT TO EXISTING 18" RCP I.E. 991.05
989.9	OUTLET NO. 13	D	.0044	989.6	18" RCP	65'		1-18" RCP	CONNECT TO EXISTING 12" VCP I.E. 995.41
•	OUTLET NO. 14	•	.0044	9[illegible]6.4	18" RCP	3-30'		6-18" RCP	•
989.3	OUTLET NO. 15	D	.0018	9[illegible]9.2	36" RCP	53'		1-36" RCP	CONNECT TO EXISTING 36" RCP I.E. 994.4
990.6	OUTLET NO. 16	D	.0023	9[illegible]0.4	30" RCP	58'		1-30" RCP	CONNECT TO EXISTING 30" RCP I.E. 997.0
992.4	OUTLET NO. 17	E	.0018	992.3	36" RCP	20'		•	•
992.2	OUTLET NO. 18	REF. 1	.003	992.1	18" RCP	10'		•	•
992.3	OUTLET NO. 19	REF. 1	.003	992.2	18" RCP	18'		•	•
•	•	•	•	•	•	•		•	•



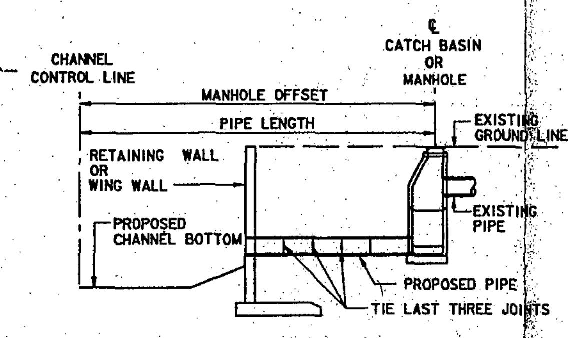
DETAIL
MANHOLE OR CA
TYPE 1
NOT TO SCALE



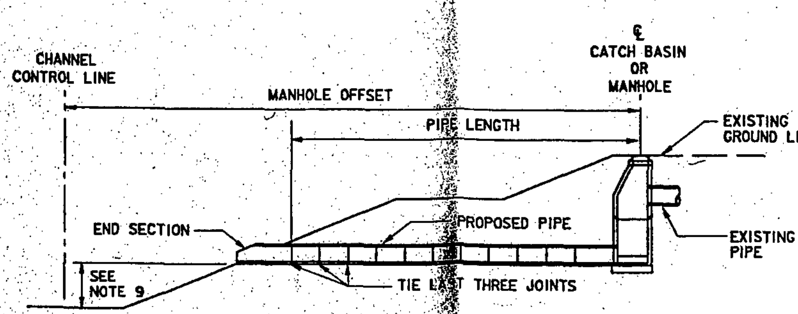
DETAIL
MANHOLE OR CA
TYPES 2, 3, 4
NOT TO SCALE



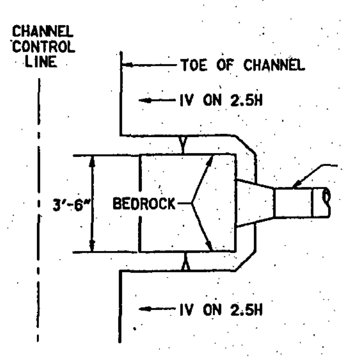
TYPICAL SECTION
STORM SEWER OUTLET
TYPE C
NOT TO SCALE



TYPICAL SECTION
STORM SEWER OUTLET
TYPE E
NOT TO SCALE



TYPICAL SECTION
STORM SEWER OUTLET
TYPE D
NOT TO SCALE



SECTION A
NOT TO SCALE

NOTES:

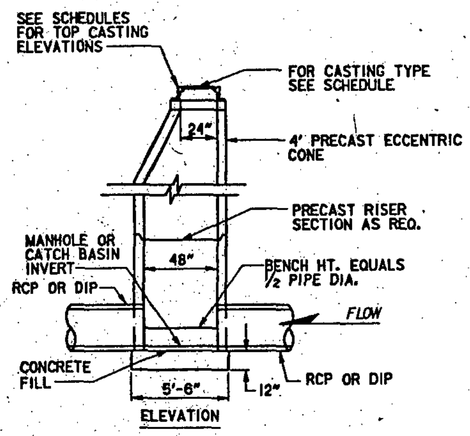
1. ALL R-1659 CASTINGS
2. THE PIPE IS LOCATED
3. THE CENTER PIPE IS L
4. CASTING TYPES ARE N
5. MANHOLES ARE TO BE
6. STATIONS AND OFFSET ARE NOT EXACT BUT TO EXISTING LINES SH
7. ANGLES ARE MEASUREC
8. THE LOCATION REFERS MANHOLES, LOCATION CONNECTION OR REMO
9. THREE FEET EXCEPT F
10. THE WIDTH OF EXPOSE THE HEADWALL.

REFERENCES:

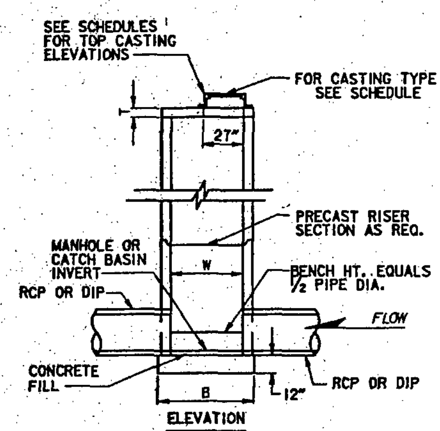
1. U.S. 14 BRIDGE
2. STORM SEWER OUTLETS

SYMBOL	
AE APPROVING OFFICIAL:	
DESIGNED: CAS	
CHECKED: GVF	
DRAWN: CAS/dae	
DESIGNED: FWC	
CHECKED: SVD	CAD FILE
DATE: MAY 92	SPEC NO:

REMARKS
(EX)ISTING 12" RCP I.E.
(EX)ISTING 21" RCP I.E. 981.3
(EX)ISTING 15" VCP I.E. 981.4
(EX)ISTING 18" RCP I.E. 986.2
(EX)ISTING 15" VCP I.E. 987.7
(I.)E. AT EXISTING 24" RCP I.E. 984.4
(EX)ISTING 15" VCP I.E. 987.9
(EX)ISTING 12" RCP I.E. 990.4
(EX)ISTING 15" RCP I.E. 988.4
(E)XISTING 12" RCP I.E. 990.51
(CONNEC)TION AT EXISTING 12" CMP I.E. 990.3
(CONNE)CTION AT EXISTING 27" RCP
(E)XISTING 18" RCP I.E. 991.05
(E)XISTING 12" VCP I.E. 995.41
(E)XISTING 36" RCP I.E. 994.4
(E)XISTING 30" RCP I.E. 997.0

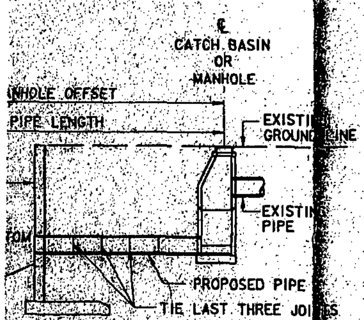


DETAIL
MANHOLE OR CATCH BASIN
TYPE 1
NOT TO SCALE



DETAIL
MANHOLE OR CATCH BASIN
TYPES 2, 3, 4
NOT TO SCALE

TYPE	DIMENSION (INCHES)		
	W	B	T
2	48	54	6
3	60	78	8
4	72	92	8



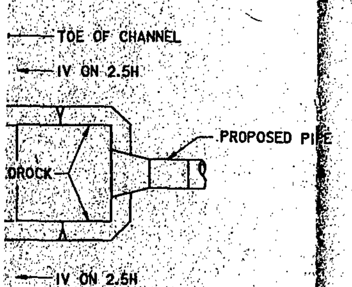
(TYP)ICAL SECTION
(STOR)M SEWER OUTLET
(NON)E
(NOT) TO SCALE

NOTES:

1. ALL R-1859 CASTINGS TO BE NON-ROCKING.
2. THE PIPE IS LOCATED PERPENDICULAR TO THE BANK SLOPE.
3. THE CENTER PIPE IS LOCATED 115° FROM CHANNEL CONTROL LINE.
4. CASTING TYPES ARE NEENAH OR EQUAL.
5. MANHOLES ARE TO BE FURNISHED WITH STEPS 16" O.C.
6. STATIONS AND OFFSETS PROVIDED FOR TYING INTO EXISTING LINES ARE NOT EXACT BUT ARE PROVIDED TO AID IN LOCATING LINES. ALL TIES TO EXISTING LINES SHALL BE FIELD LOCATED.
7. ANGLES ARE MEASURED IN A CLOCKWISE DIRECTION FROM THE EXISTING PIPE.
8. THE LOCATION REFERS TO NEW MANHOLE. WHERE THERE ARE NO NEW MANHOLES, LOCATION REFERS TO THE EXISTING PIPE AT WHICH THE CONNECTION OR REMOVAL OCCURS.
9. THREE FEET EXCEPT FOR MH NO. 13 WHICH IS 4.6'.
10. THE WIDTH OF EXPOSED BEDROCK IS THE SAME AS THE WIDTH OF THE HEADWALL.

REFERENCES:

	PLATE NO.
1. U.S. 14 BRIDGE	42
2. STORM SEWER OUTLETS	33



(PLA)N
(SC)ALE

A

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

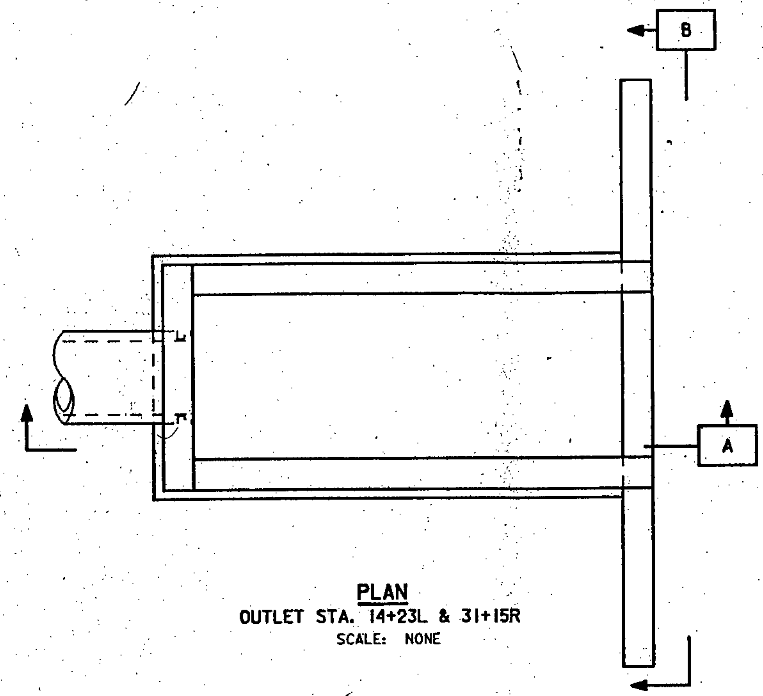
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

STAGE 4-BEAR CREEK

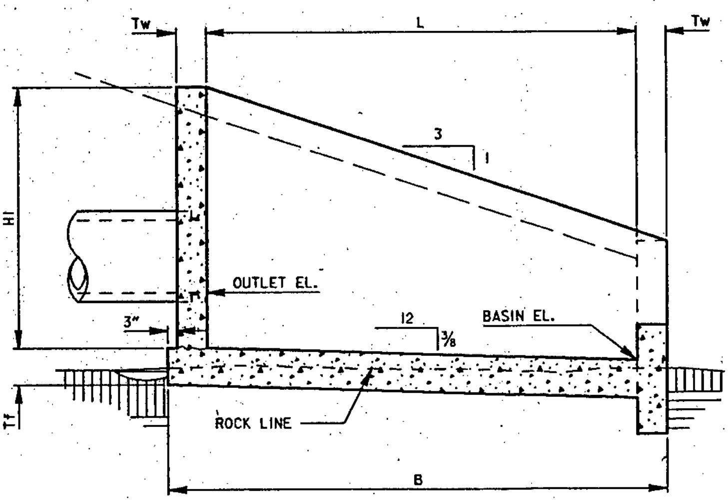
STORM SEWER SCHEDULE AND OUTLETS

ED-D	DESIGNED:	CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	CAS/dae
ED-GH	DESIGNED:	FWC
ED-GH	CHECKED:	SVD

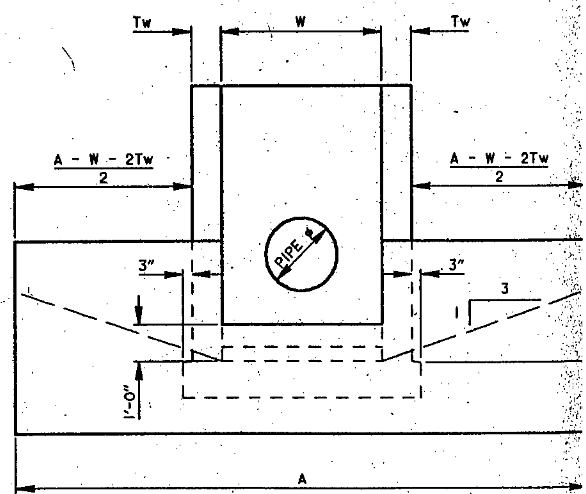
DATE: MAY 92
CAD FILE NAME: r4strsch.dgn
SPEC NO:
DRAWING NUMBER: PLATE 41
SHT 41 OF 53



PLAN
OUTLET STA. 14+23L & 31+15R
SCALE: NONE



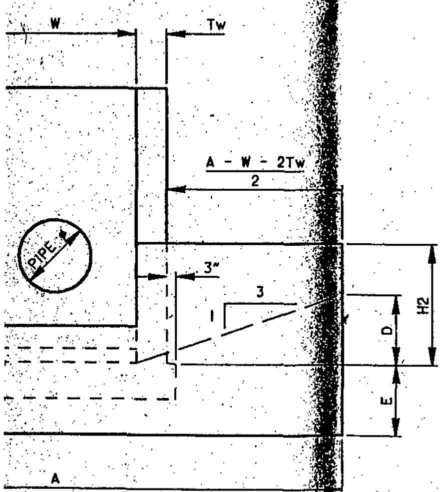
SECTION
OUTLET STA. 14+23L & 31+15R
A
SCALE: NONE



ELEVATION
OUTLET STA. 14+23L & 31+15R
B
SCALE: NONE

OUTLET SCHEDULE

OUTLET NO.	STATION	PIPE ø	MATERIAL	ELEVATIONS		DIMENSIONS (FT)								
				OUTLET	BASIN	A	B	D	E	H1	H2	L	Tf	T
6	14+23L	24"	RCP	984.40	982.50	16.0	13.9	1.9	2.0	7.2	3.3	12.0	12"	[illegible]
11	31+15R	18"	RCP	991.05	989.75	15.0	10.9	1.3	2.0	6.2	3.0	9.0	12"	[illegible]



1+23L & 31+15R **B**

SCALE: 3/8" = 1'-0"

SYMBOL	DESCRIP

AE APPROVING OFFICIAL:

FLOOD C

S

PLA

ED-D	DESIGNED: BGS
	CHECKED: DMT
	DRAWN: LKT
ED-GH	DESIGNED: XXX/XXX
	CHECKED: XXX/XXX
DATE: 04-22-92	

CAD FILE NAME: ROCH4

SPEC NO:

OUTLET SCHEDULE

ERIAL	ELEVATIONS		DIMENSIONS (FT)											BACKWALL HANDRAIL
	OUTLET	BASIN	A	B	D	E	H1	H2	L	Tf	Tw	W		
CP	984.40	982.50	16.0	13.9	1.9	2.0	7.2	3.3	12.0	12"	10"	4.5		YES
CP	991.05	989.75	15.0	10.9	1.3	2.0	6.2	3.0	9.0	12"	10"	3.5		

0 2 4 6

SCALE: 3/8" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
STORM SEWER OUTLET
PLAN, ELEVATION AND SECTION

ED-D	DESIGNED:	BGS
	CHECKED:	DMT
	DRAWN:	LKT
ED-GH	DESIGNED:	XXX/XXX
	CHECKED:	XXX/XXX

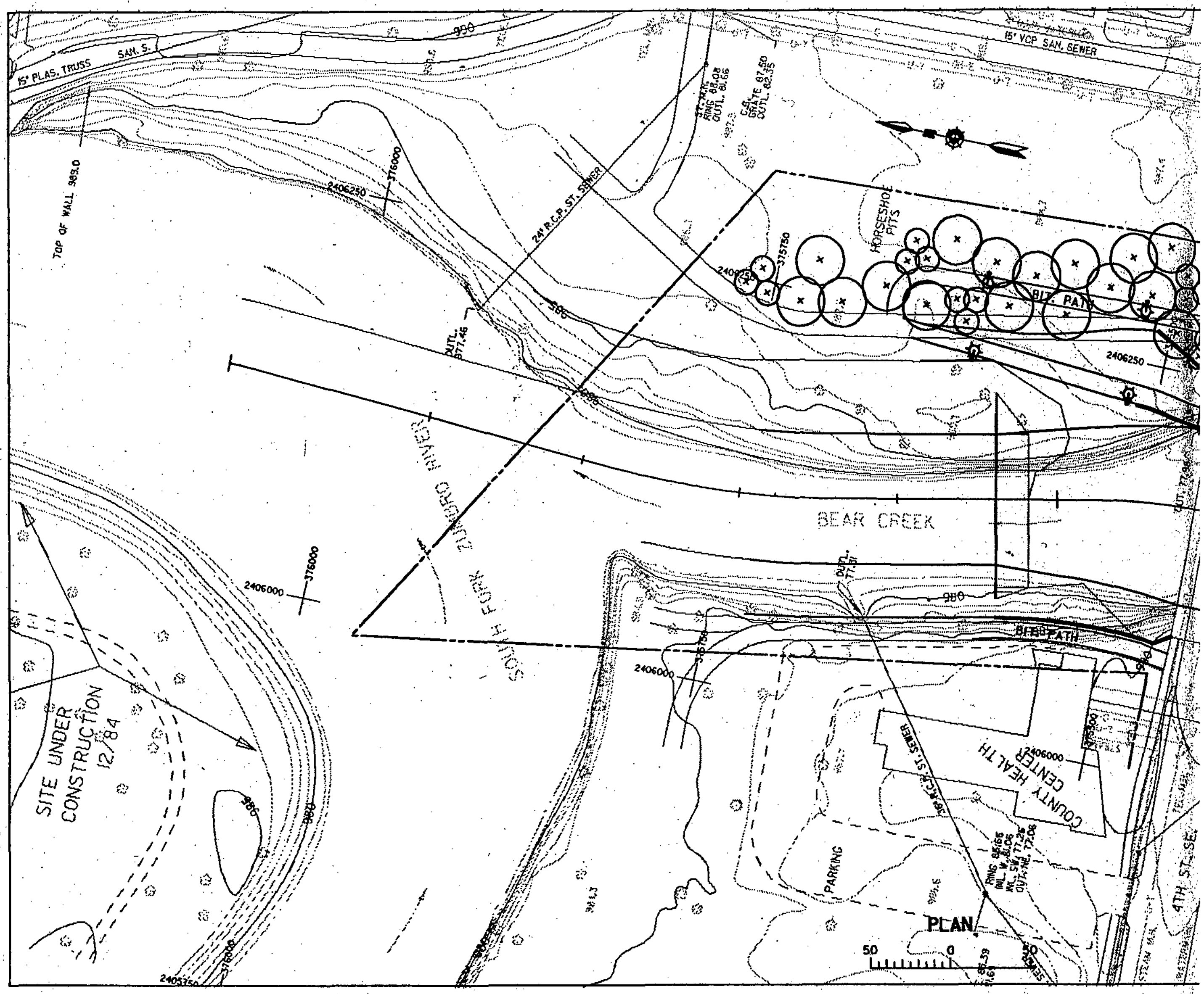
DATE: 04-22-92

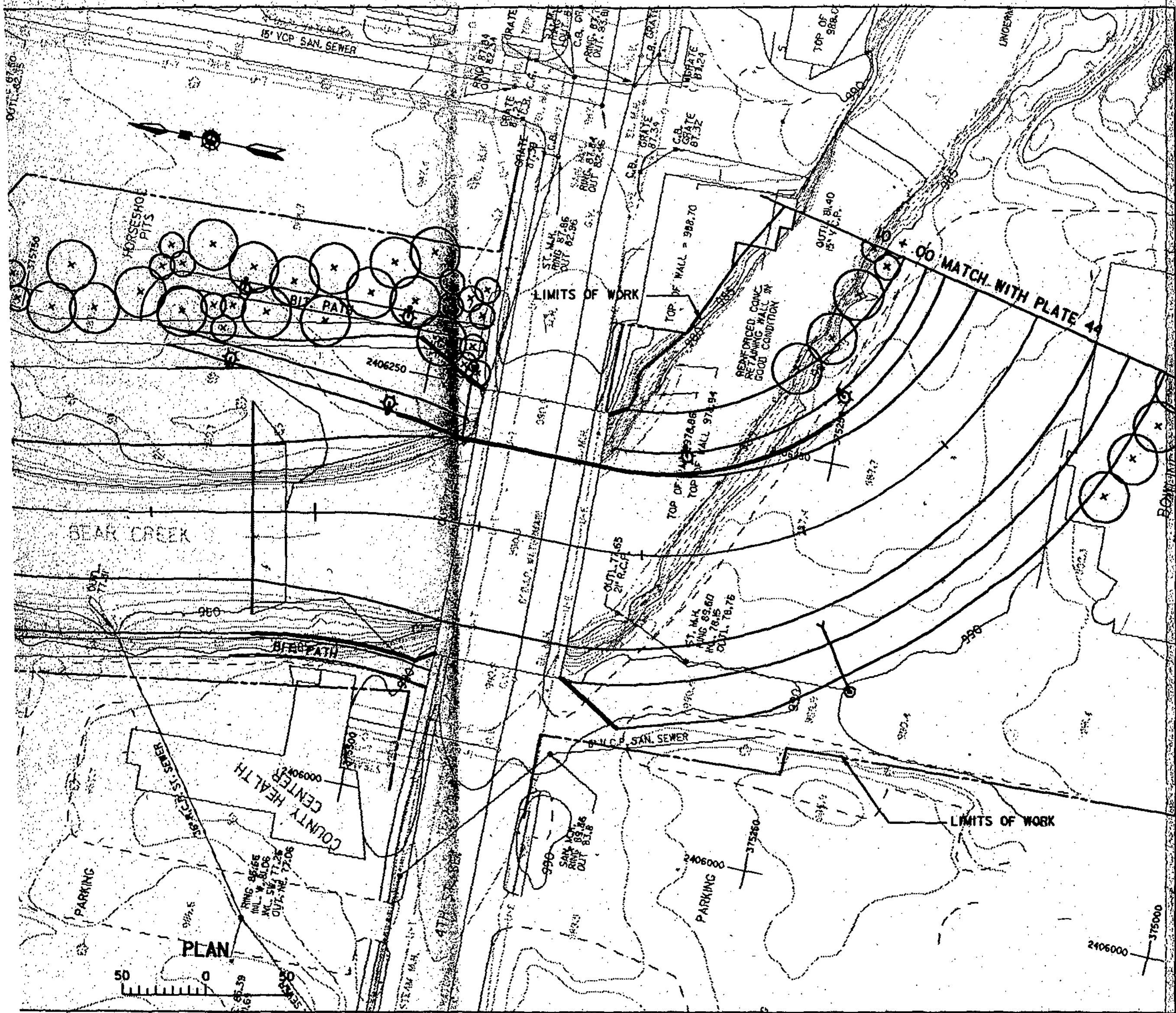
CAD FILE NAME: ROCH4-5.DGN

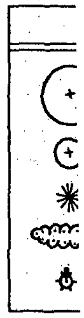
SPEC NO:

DRAWING NUMBER: PLATE 42

SHT 42 OF 53


15" PLAS. TRUSS SAN. S.
15" VCP SAN. SEWER
TOP OF WALL 989.0
24" R.C.P. ST. SEWER
HORSESHOE PITS
BIT. PATH
BEAR CREEK
SOUTH FORK ZUMBRO RIVER
SITE UNDER CONSTRUCTION 12/84
COUNTY HEALTH CENTER
PARKING
PLAN
4TH ST. SE.
2406250
376000
2406000
375750

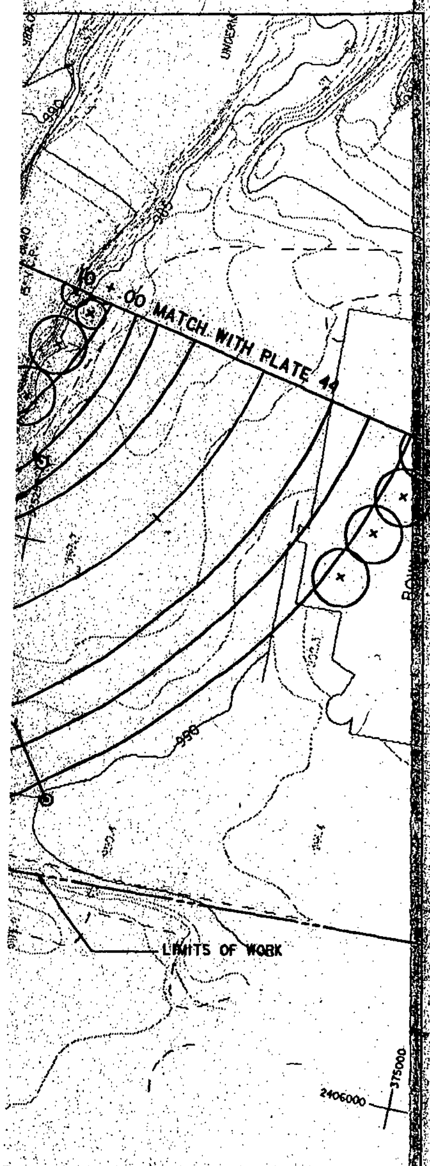




SYMBOL	

AE APPROVING OFFICIAL:

DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: FJB/LCW
DESIGNED: LGW
CHECKED: LGW
DATE: MAY 92



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

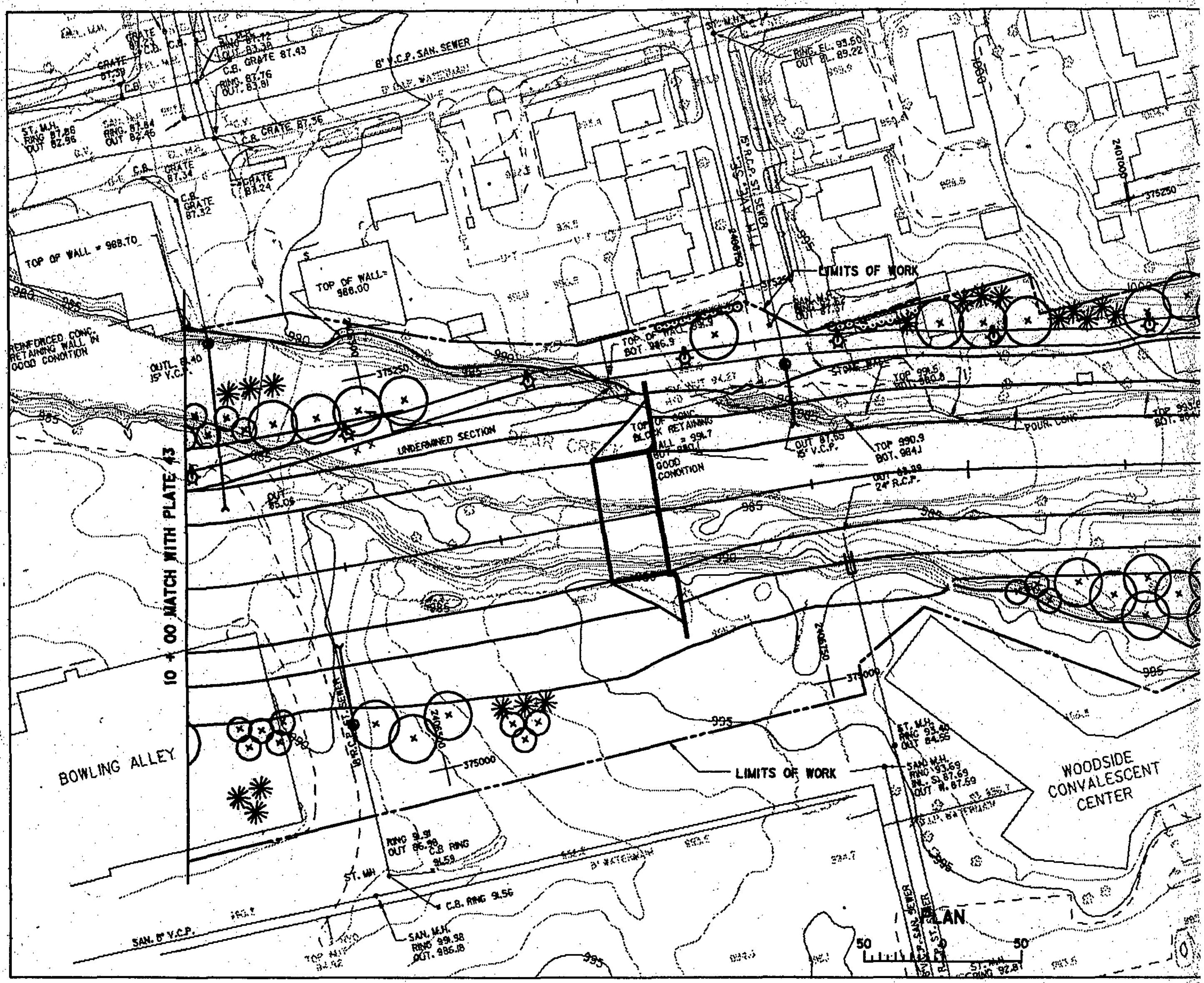
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

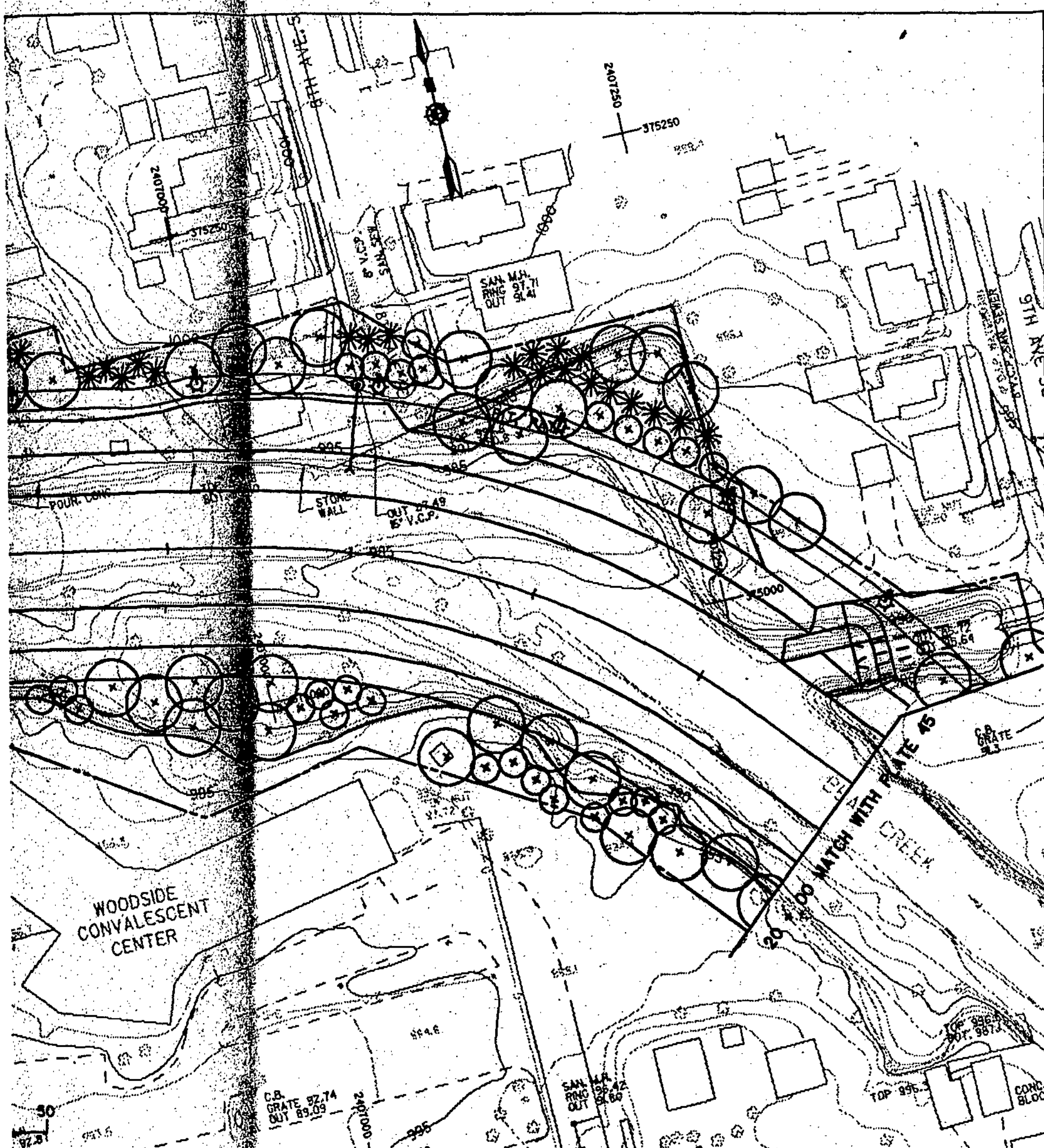
AE APPROVING OFFICIAL:

ED-D: DESIGNED: KFB/CAS; CHECKED: GVF; DRAWN: FJB/LGW
PUP: DESIGNED: LGW; CHECKED: LGW
DATE: MAY 92

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 00+00 TO 10+00

CAD FILE NAME: r4lsl.dgn
SPEC NO:
DRAWING NUMBER: PLATE 43
SHT 43 OF 53


PLAN
10 + 00 MATCH WITH PLATE 43
LIMITS OF WORK
LIMITS OF WORK
BOWLING ALLEY
WOODSIDE CONVALESCENT CENTER
TOP OF WALL = 988.70
TOP OF WALL= 986.00
REINFORCED CONC. RETAINING WALL IN GOOD CONDITION
UNDERMINED SECTION
TOP OF CONC. BLOCK RETAINING WALL = 994.7
GOOD CONDITION
8" V.C.P. SAN. SEWER
SAN. 8" V.C.P.
8" WATERMAIN
C.B. RING 91.56
375000
375250
50
0
50



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION

DEPART
ST. PAUL DI
ST

AE APPROVING OFFICIAL:

DESIGNED:	KFB/CAS
CHECKED:	GVF
DRAWN:	FJB/LGW
DESIGNED:	LGW
CHECKED:	LGW
DATE:	MAY 92

DESIGN MEMORANDU

FLOOD CONTROL - SOUTH FO

ROCHESTER, MINI

STAGE 4-BEAF

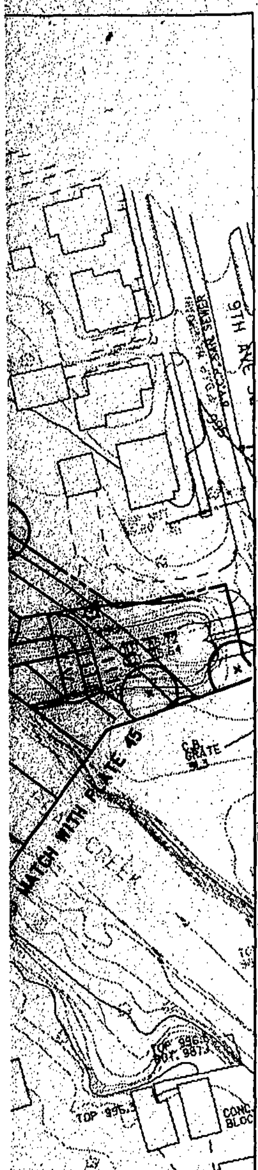
LANDSCAPE AND LIG

STATION 10+00 T

CAD FILE NAME: r4ls2.dgn

SPEC NO:

DRAWING



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

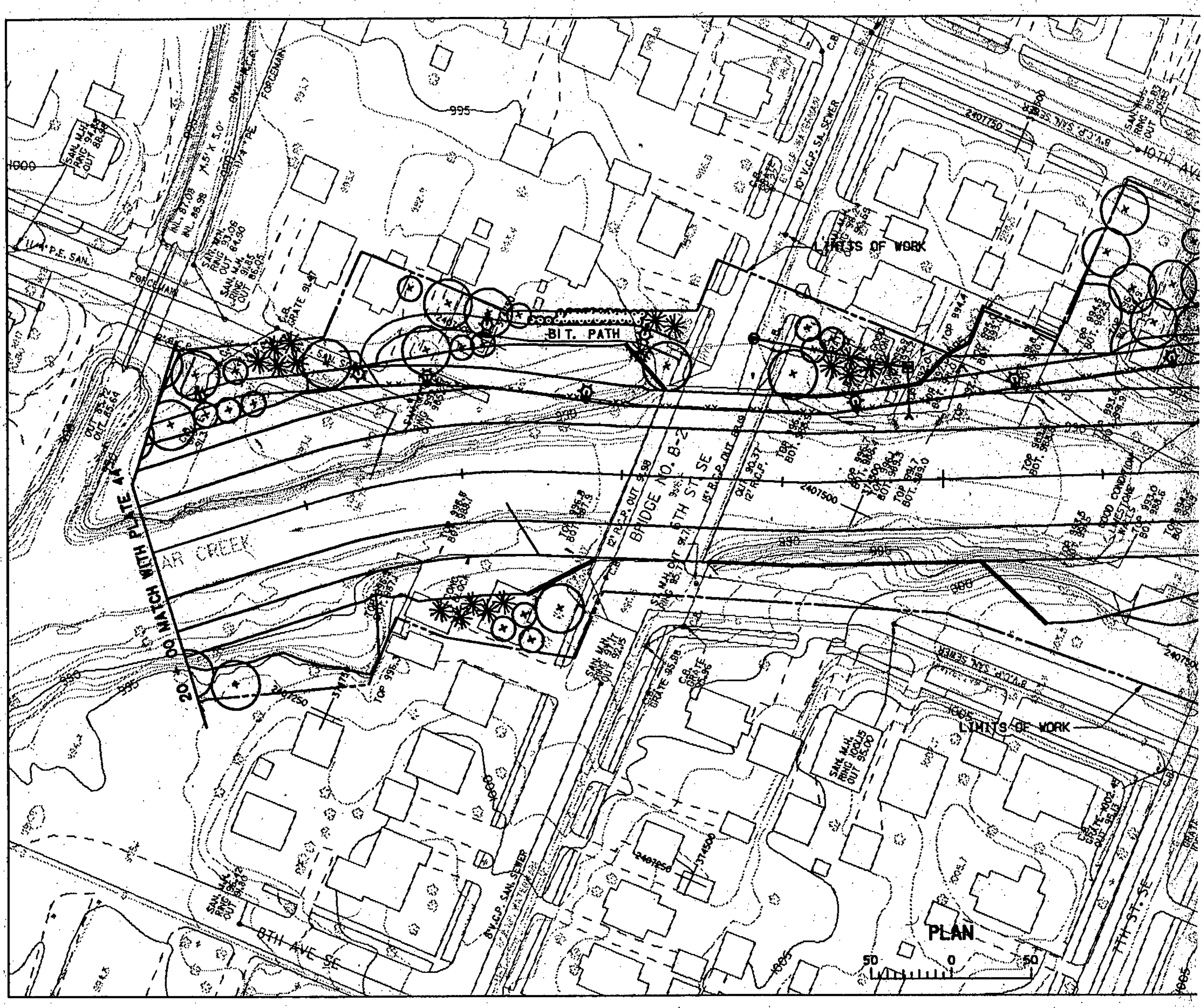
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

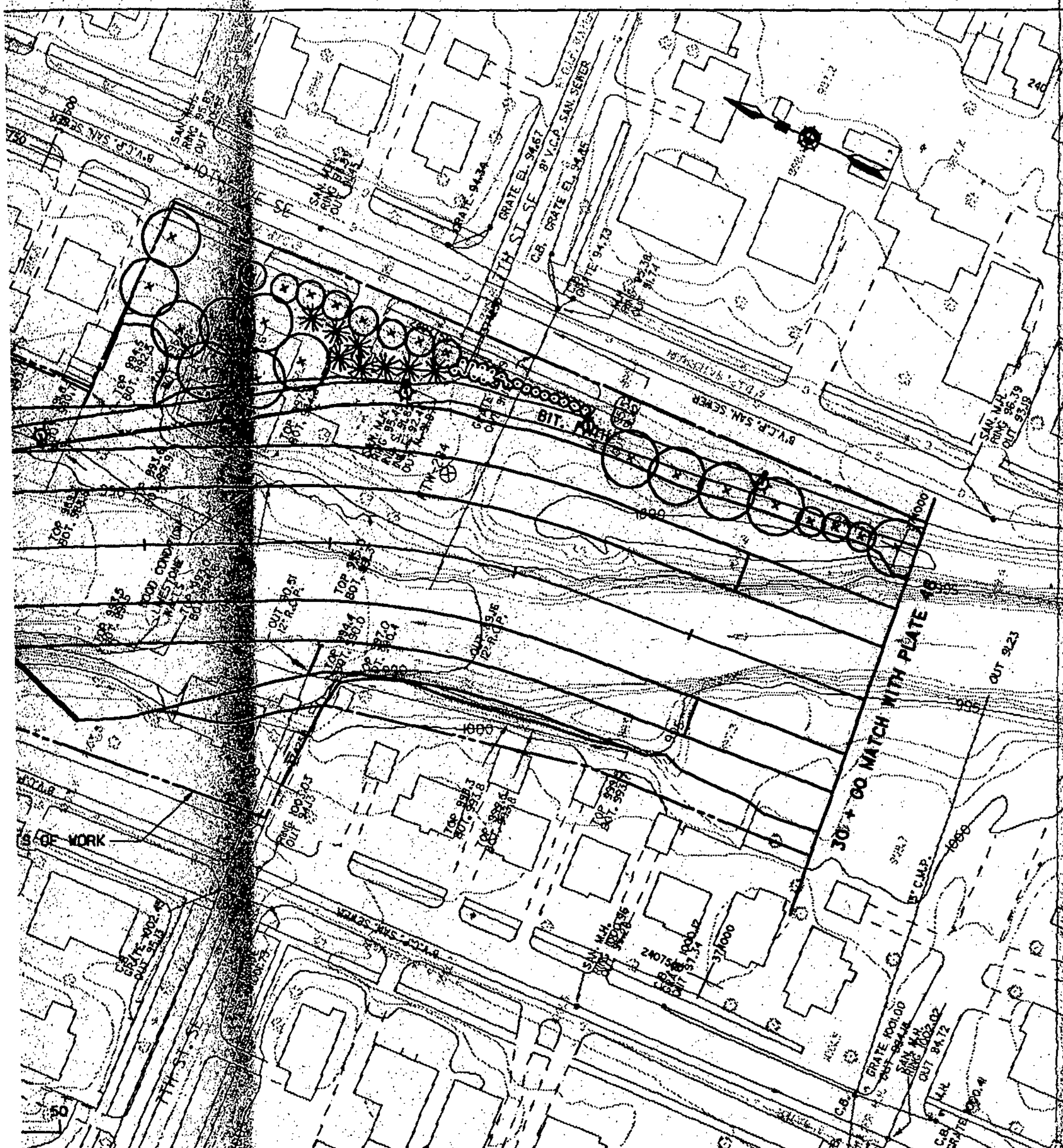
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 10+00 TO 20+00

DESIGNED:	KFB/CAS
CHECKED:	GVF
DRAWN:	FJB/LGW
DESIGNED:	LGW
CHECKED:	LGW
DATE:	MAY 92

CAD FILE NAME: r4ls2.dgn
SPEC NO:
DRAWING NUMBER: PLATE 44
SHT 44 OF 53



LIMITS OF WORK
BIT. PATH
BRIDGE NO. B-2
6TH ST. SE
MATCH WITH PLATE 4
8TH AVE SE
7TH ST. SE
10TH AVE
LIMITS OF WORK
PLAN
50
0
50



LANDSCAPE AND LIGHTING LI

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAM
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION

DEPA
ST. PAUL

AE APPROVING OFFICIAL:

DESIGN MEMORAN
FLOOD CONTROL - SOUTH
ROCHESTER, M
STAGE 4-BE
LANDSCAPE AND L
STATION 20+00

DESIGNED:	KFB/CAS
CHECKED:	GVF
DRAWN:	FOB/LGW
DESIGNED:	LGW
CHECKED:	LGW
DATE:	MAY/92

CAD FILE NAME: r4ls3.dgn
SPEC NO.
DRAWIN

LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

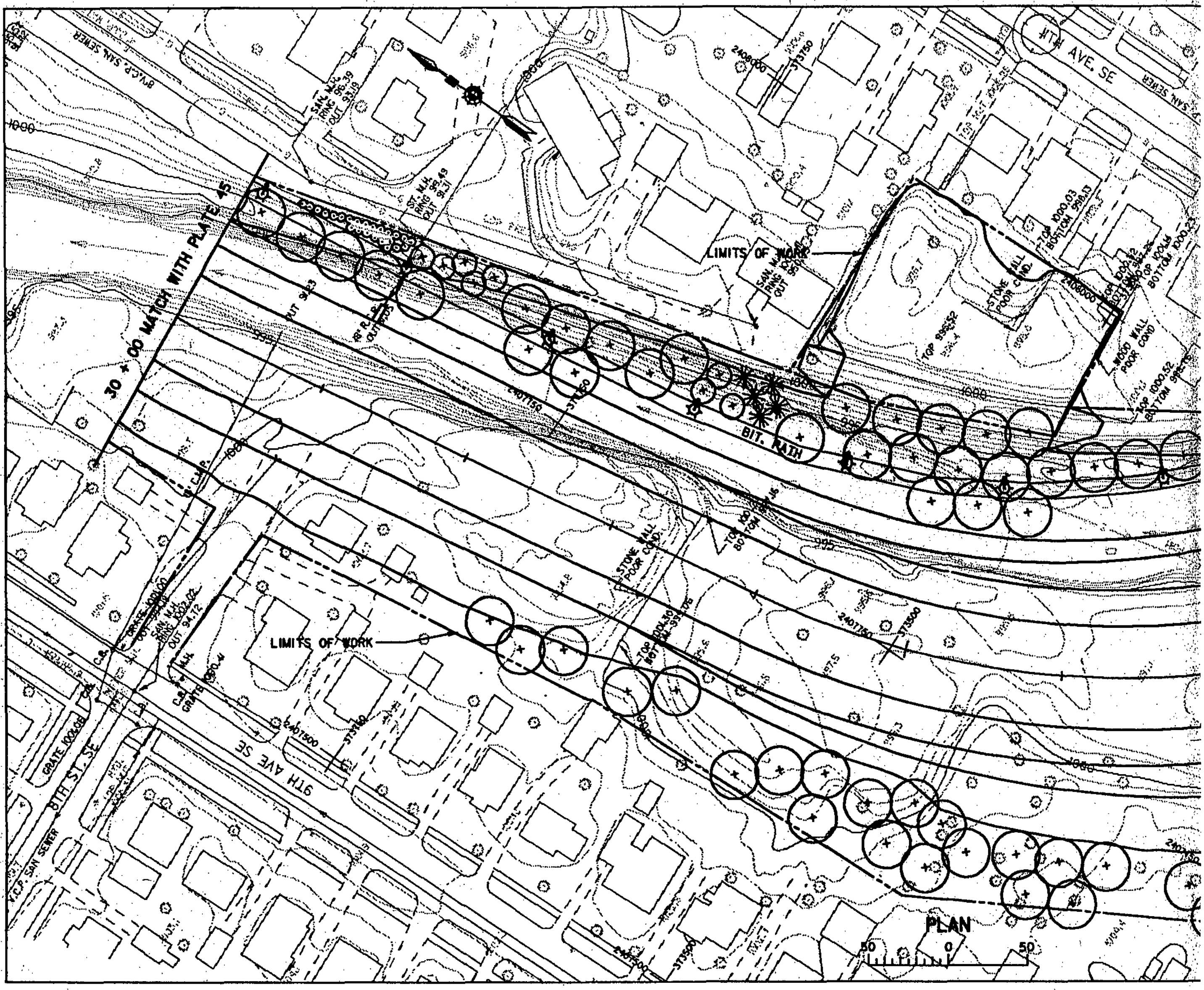
AE APPROVING OFFICIAL:

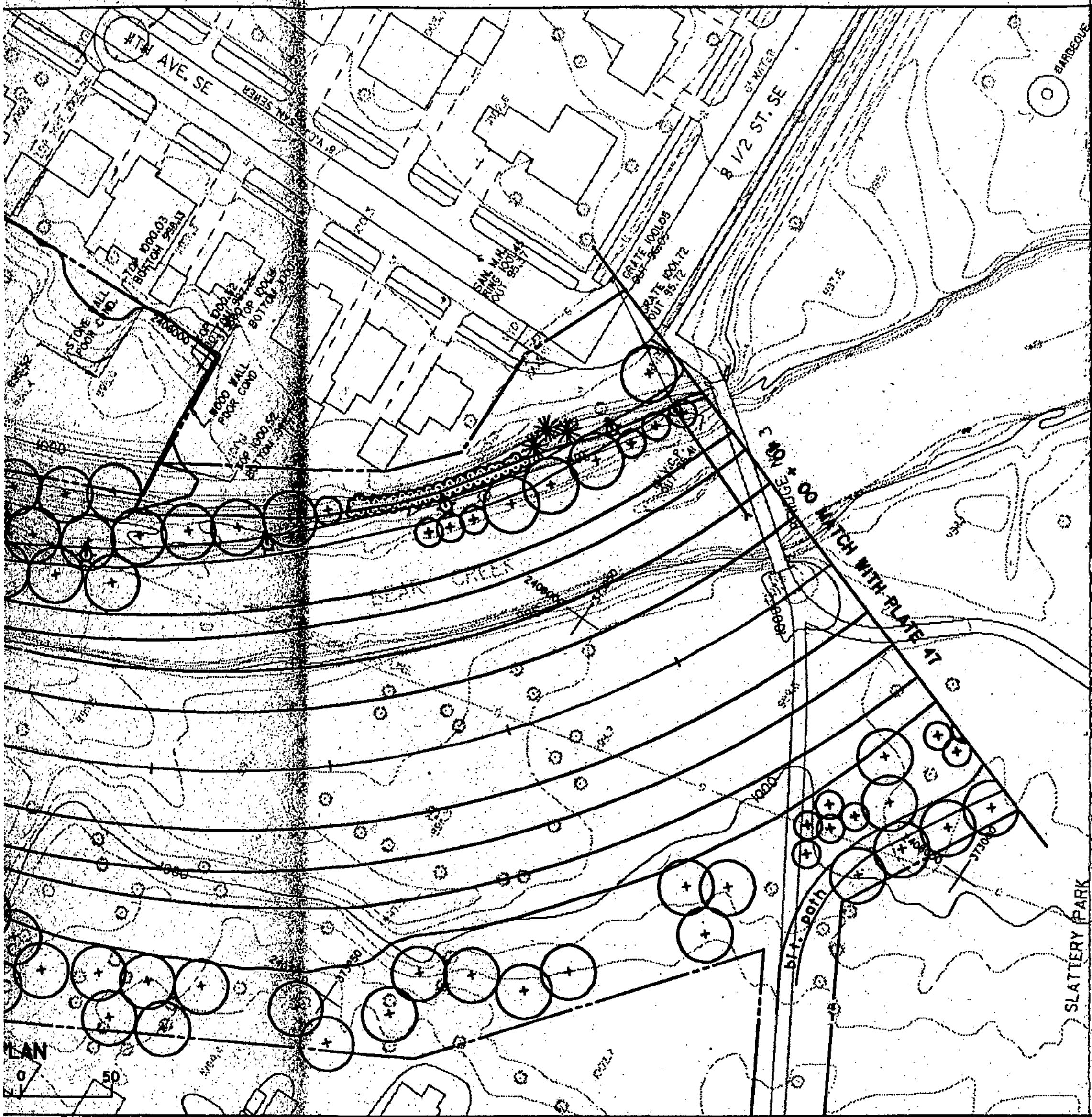
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 20+00 TO 30+00

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
PUP	CHECKED:	LGW
	DATE:	MAY 92

CAD FILE NAME: r4ls3.dgn	DRAWING NUMBER: PLATE 45	SHT 45 OF 53
SPEC NO:		


30 + 00 MATCH WITH PLATE 45
LIMITS OF WORK
LIMITS OF WORK
BIT. PATH
STONE WALL POOR COND.
STONE WALL POOR COND.
WOOD WALL POOR COND.
9TH AVE SE
8TH ST. SE
V.C.P. SAN SEWER
PLAN
50
0
50



LANDSCAPE AND LIGHT

- LARGE CANOPY TREE
- SMALL UNDERSTORY/
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION

AE APPROVING OFFICIAL:

ED-D
DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: FJB/LGW

RUP
DESIGNED: LGW
CHECKED: LGW

DATE: MAY 92

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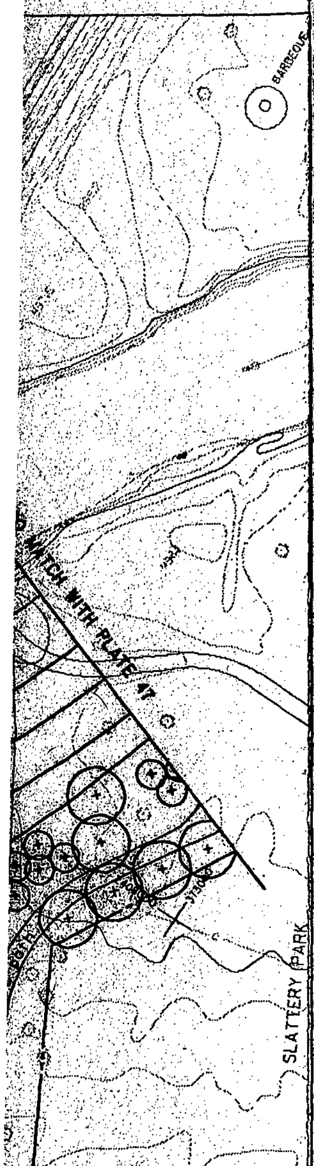
CAD FILE NAME: r4ls4.dgn
SPEC NO:



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

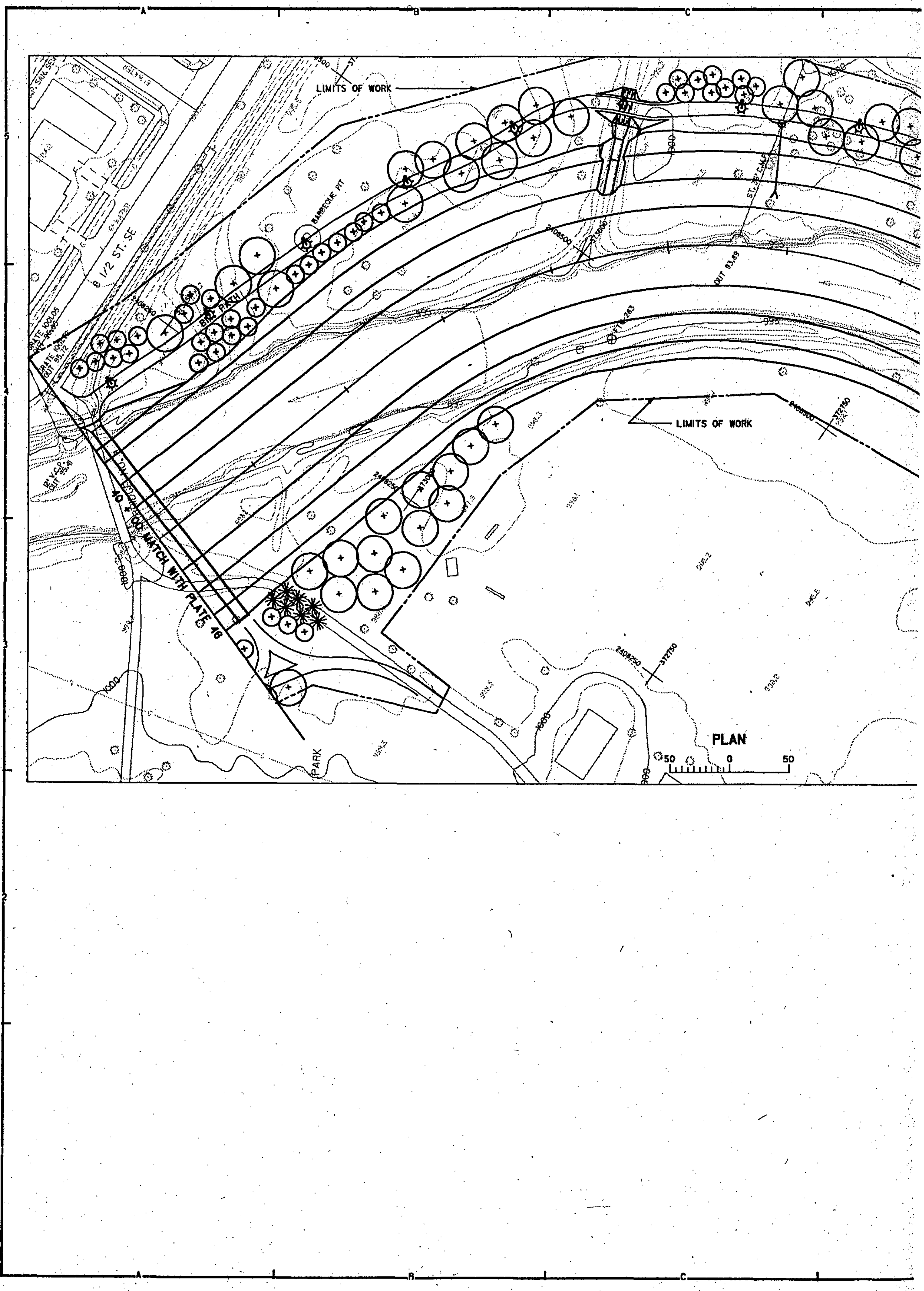
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

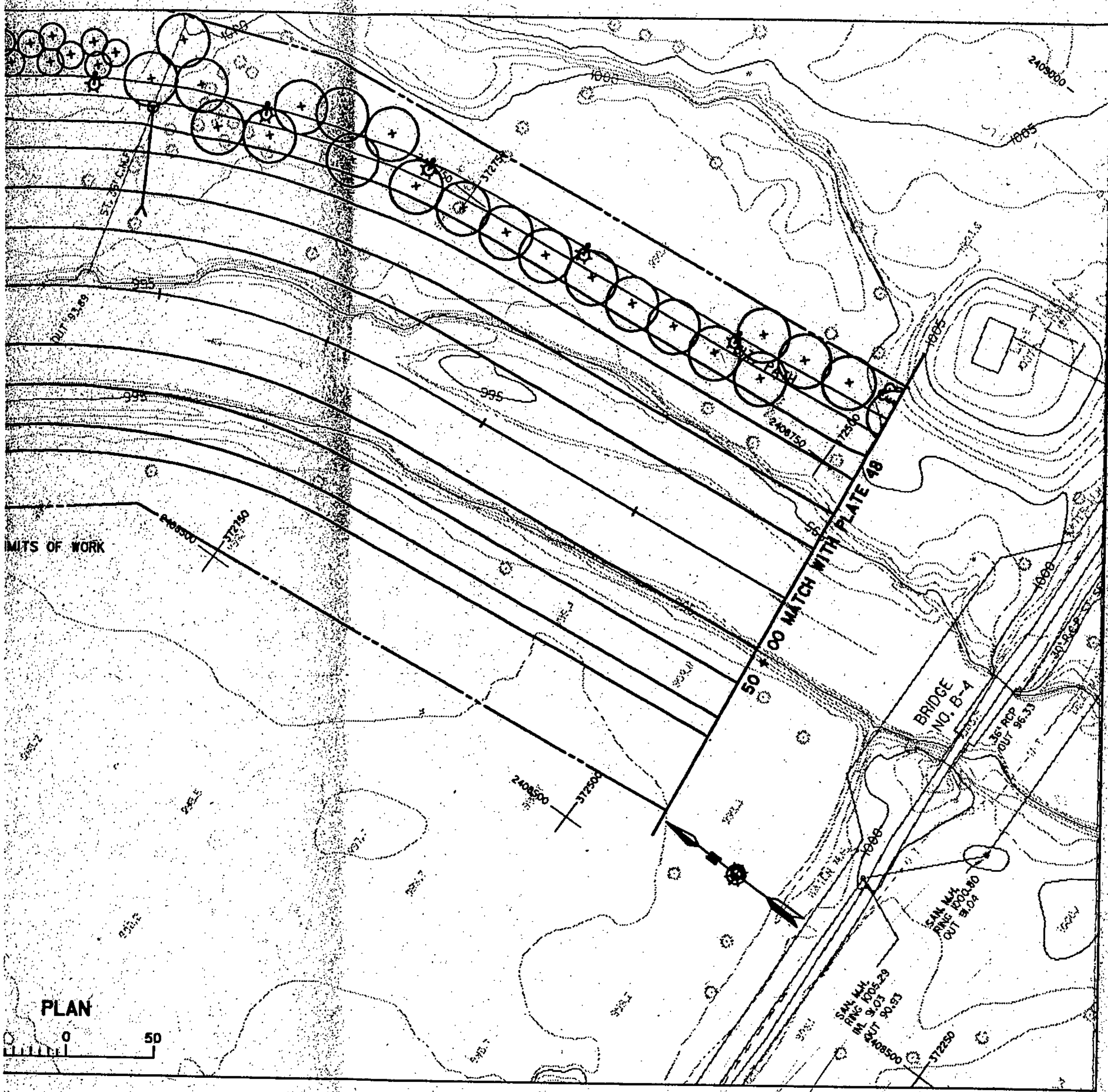
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 30+00 TO 40+00

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
PUP	CHECKED:	LGW
DATE: MAY 92		

CAD FILE NAME: r4ls4.dgn
SPEC NO:
DRAWING NUMBER: PLATE 46
SHT 46 OF 53



LIMITS OF WORK
8 1/2 ST. SE
BIKE PATH
BARBECUE PIT
LIMITS OF WORK
MATCH WITH PLATE 46
PARK
PLAN
50
0
50



LANDSCAPE AND

LARGE CANOPY

SMALL UNDERS

EVERGREEN T

LARGE SHRUB

LIGHTS

SYMBOL	DESCR

AE APPROVING OFFICIAL:

FLOOD CC

LAN

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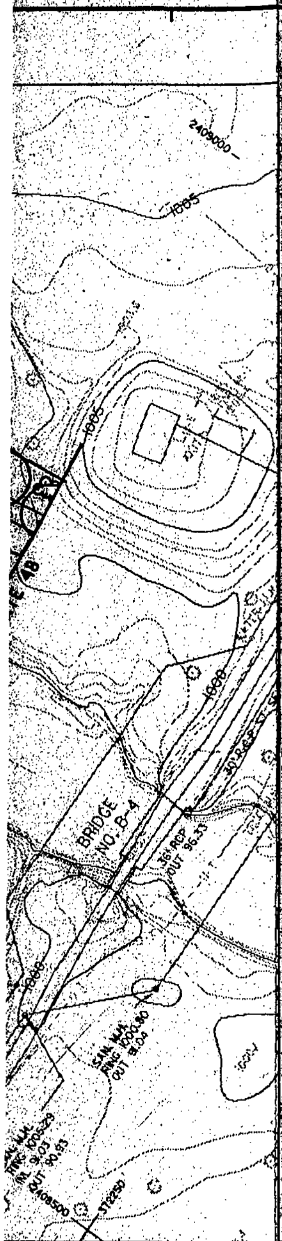
DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: FJB/LGW
DESIGNED: LGW
CHECKED: LGW
DATE: MAY 92

CAD FILE NAME: r4ls5.
SPEC NO:



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

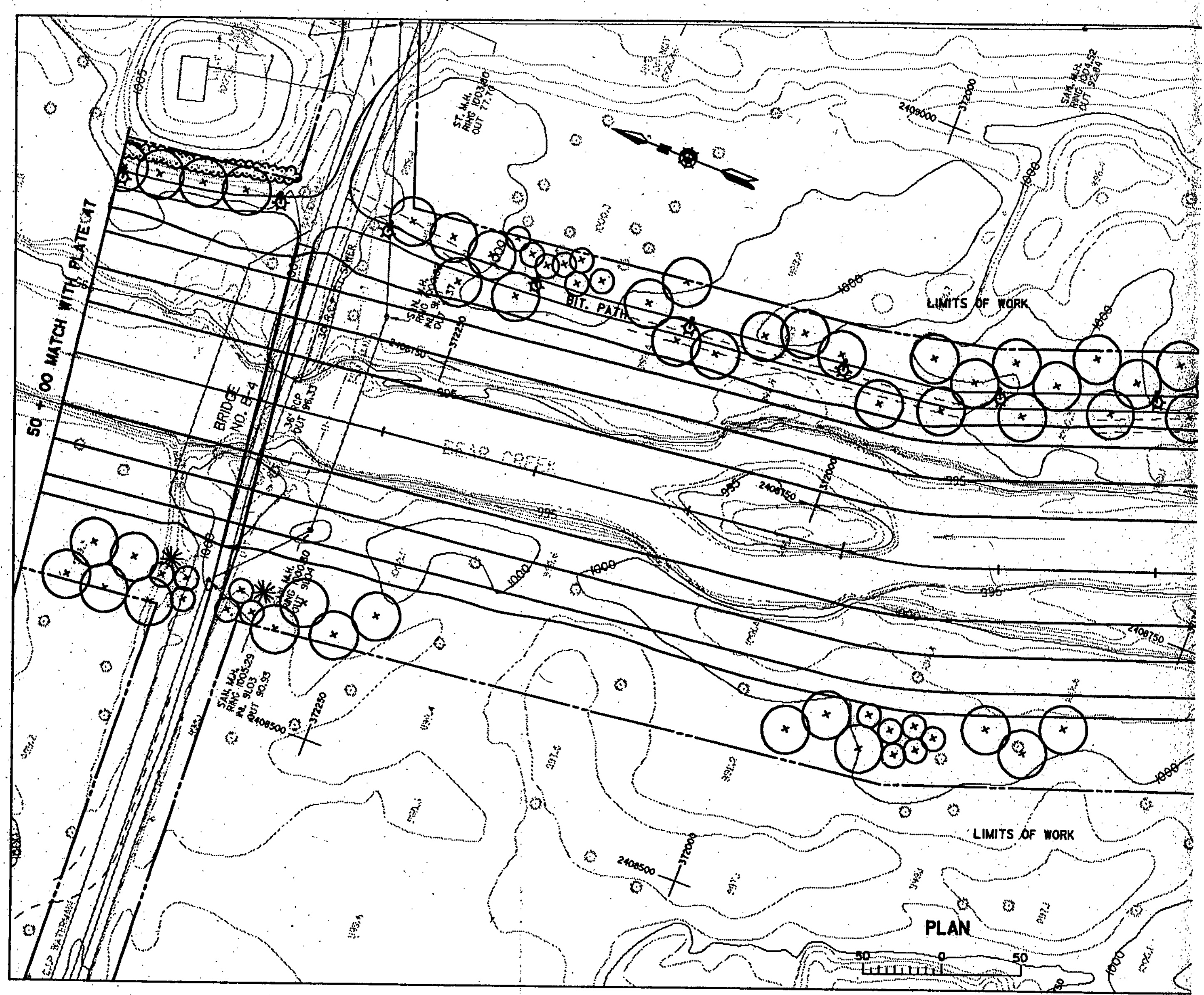
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

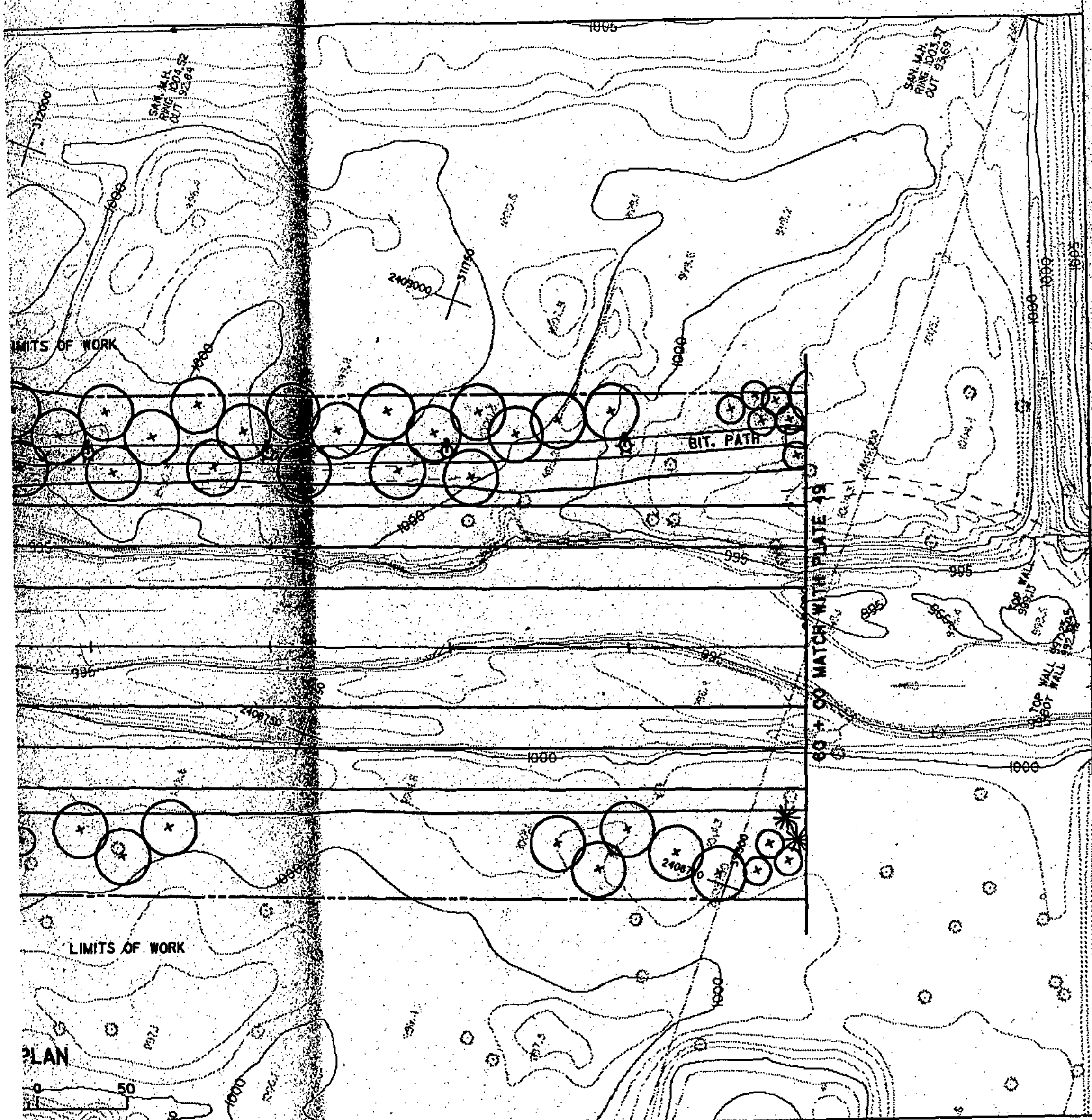
AE APPROVING OFFICIAL: ____________

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 40+00 TO 50+00

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
PUP	CHECKED:	LGW

DATE: MAY 92 | CAD FILE NAME: r4ls5.dgn | SPEC NO: | DRAWING NUMBER: PLATE 47 | SHT 47 OF 53


50 + 00 MATCH WITH PLATE 47
BRIDGE NO. B-4
BEAR CREEK
BIT. PATH
LIMITS OF WORK
LIMITS OF WORK
PLAN



LANDSCAPE AND LIG
LARGE CANOPY TRE
SMALL UNDERSTORY
EVERGREEN TREES
LARGE SHRUBS
LIGHTS

SYMBOL	DESCRIPTION

AE APPROVING OFFICIAL:

ED-D	DESIGNED: KFB/CAS
	CHECKED: GVF
	DRAWN: FJB/LGW
PUP	DESIGNED: LGW
	CHECKED: LGW
DATE: MAY 92	

DESIG
FLOOD CONTROL
ROC
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LANDSCA
STATIC

CAD FILE NAME: r4ls6.dgn
SPEC NO:

LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

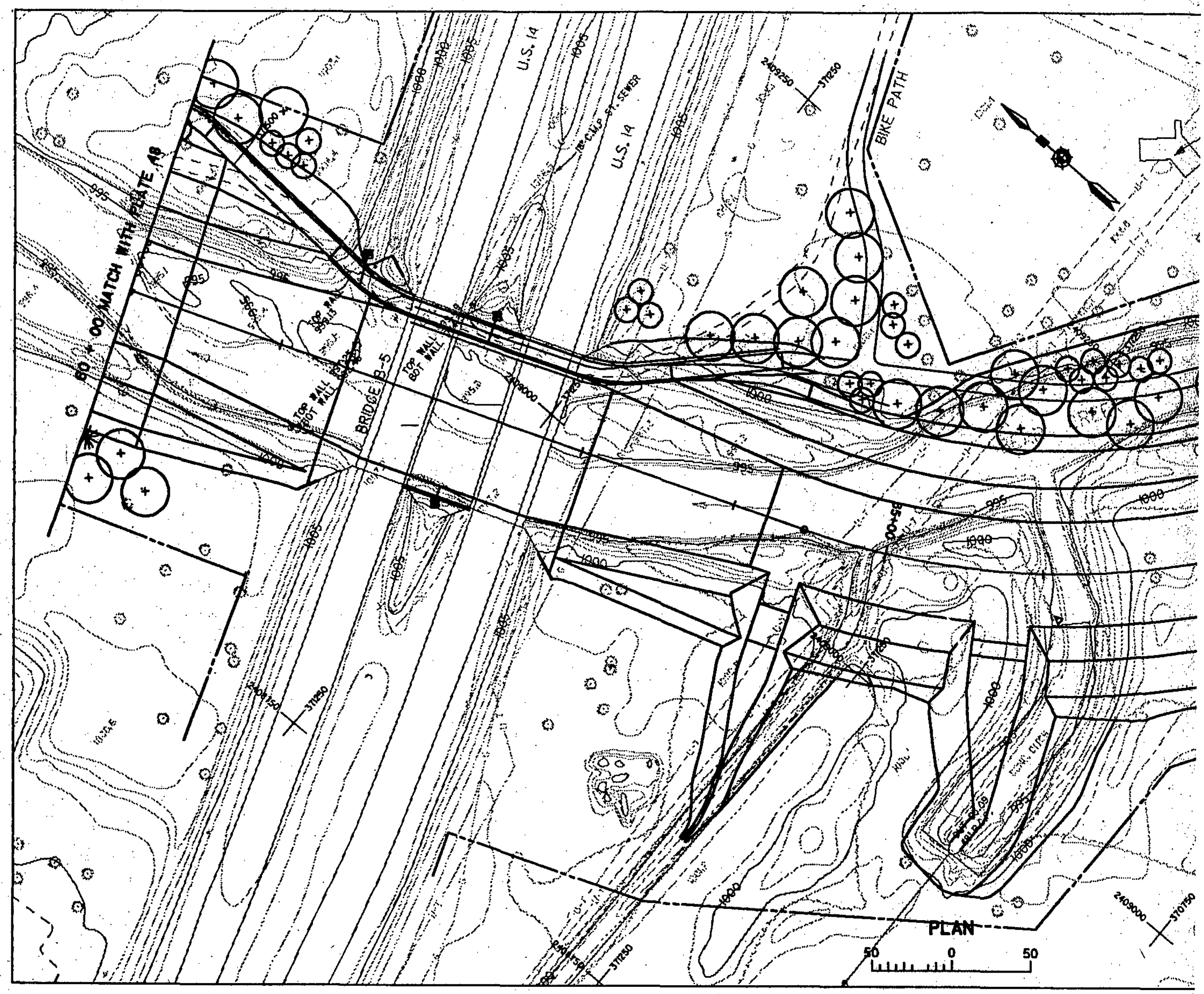
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGNED: KFB/CAS
CHECKED: GVF
DRAWN: FJB/LGW
DESIGNED: LGW
CHECKED: LGW
DATE: MAY 92

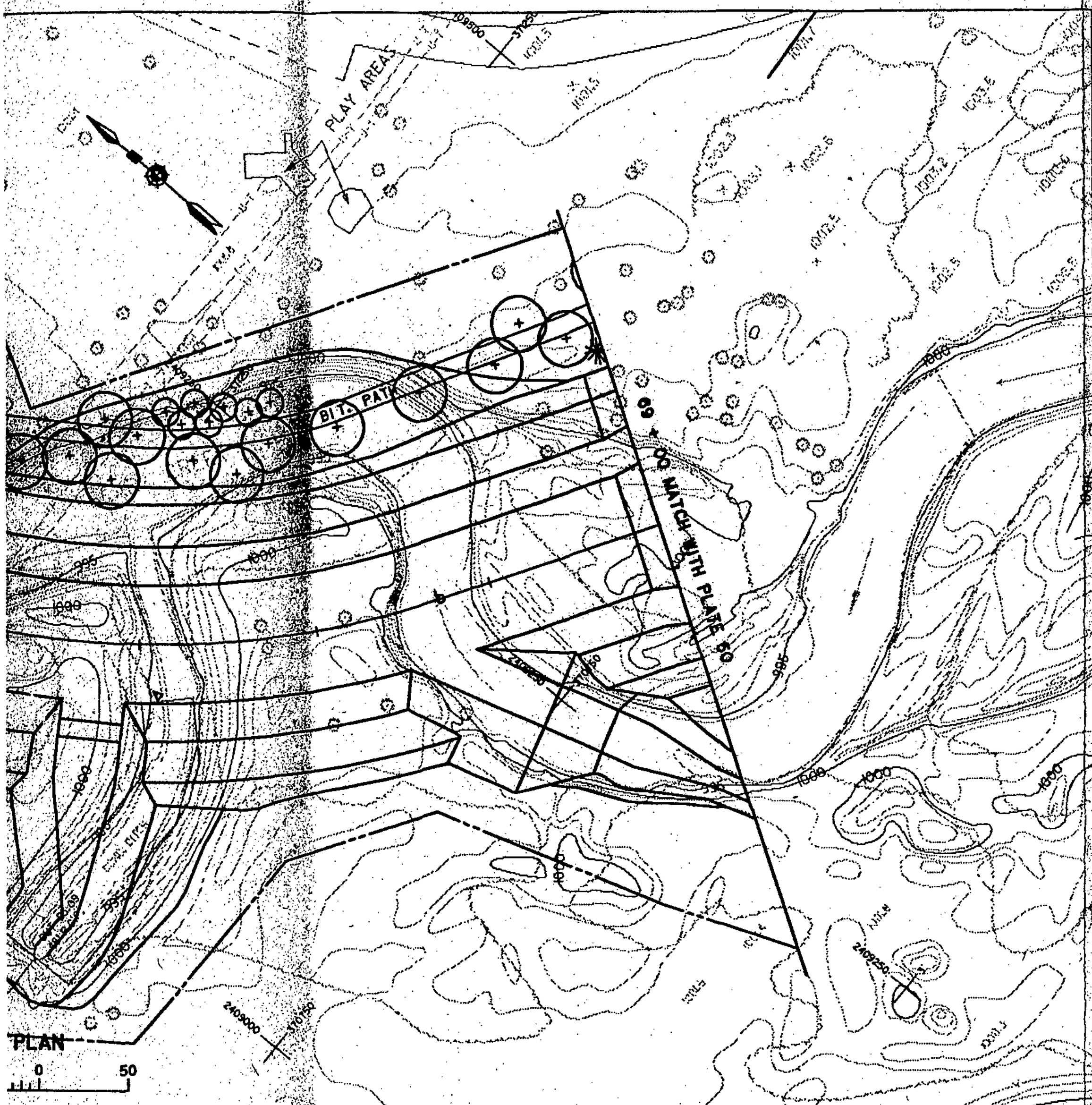
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 50+00 TO 60+00

CAD FILE NAME: r4ls6.dgn
SPEC NO:
DRAWING NUMBER: PLATE 48
SHT 48 OF 53



U.S. 14
U.S. 14
BIKE PATH
60 + 00 MATCH WITH PLATE 48
BRIDGE B-5
TOP WALL
BOT WALL
ST. SEWER
995
1000
1005
PLAN
50
0
50

D E F



LANDSCAPE AND LIG

- LARGE CANOPY TR
- SMALL UNDERSTOR
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

2

SYMBOL	DESCRIPTIO

AE APPROVING OFFICIAL:	DES FLOOD CONTR RO STA LANDSC STAT
ED-D DESIGNED: KFB/CAS CHECKED: GVF DRAWN: FJB/LGW	
PUP DESIGNED: LGW CHECKED: LGW	CAD FILE NAME: r4ls7.dgn
DATE: MAY 92	SPEC NO:

D F

LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES.
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

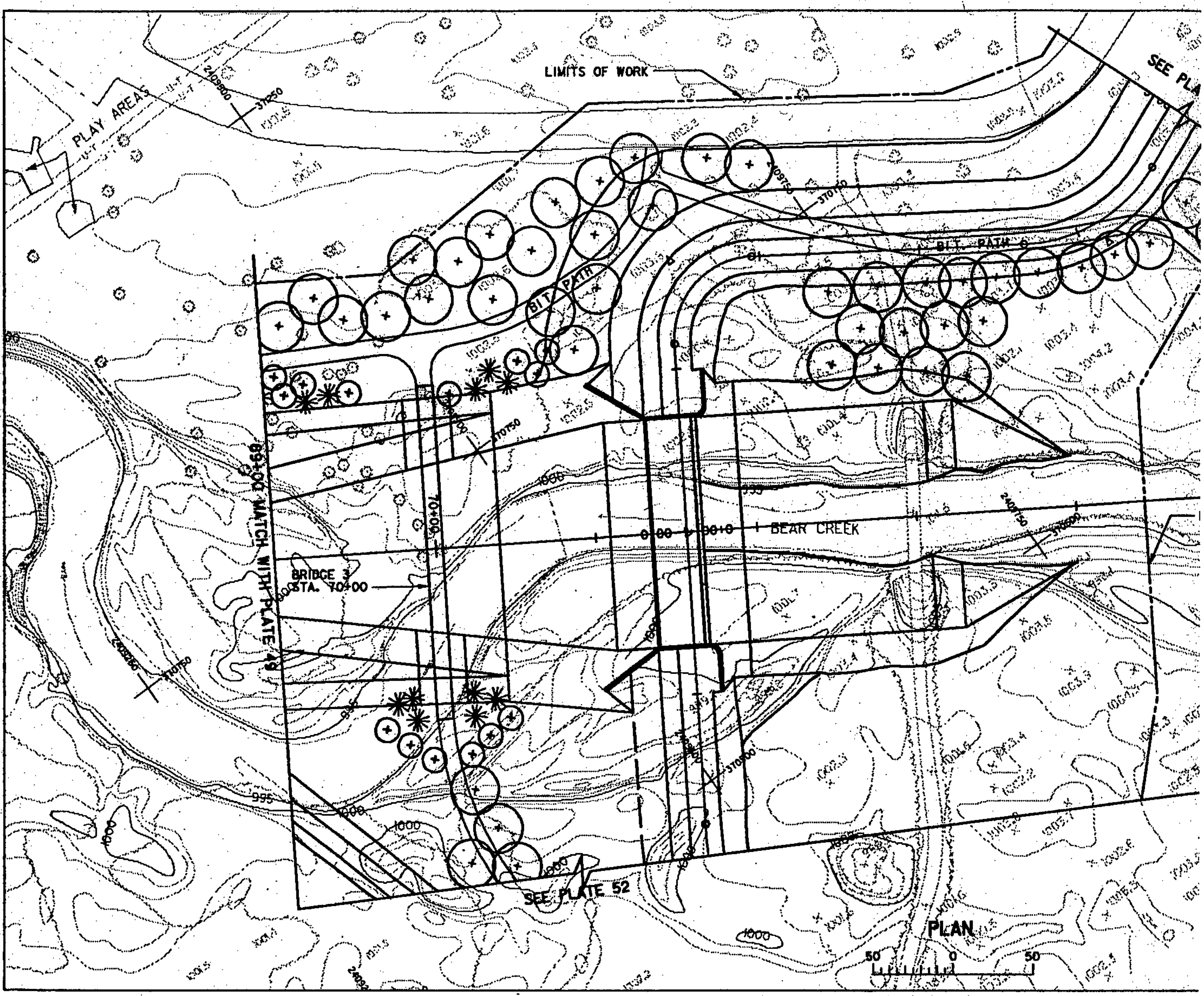
AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA

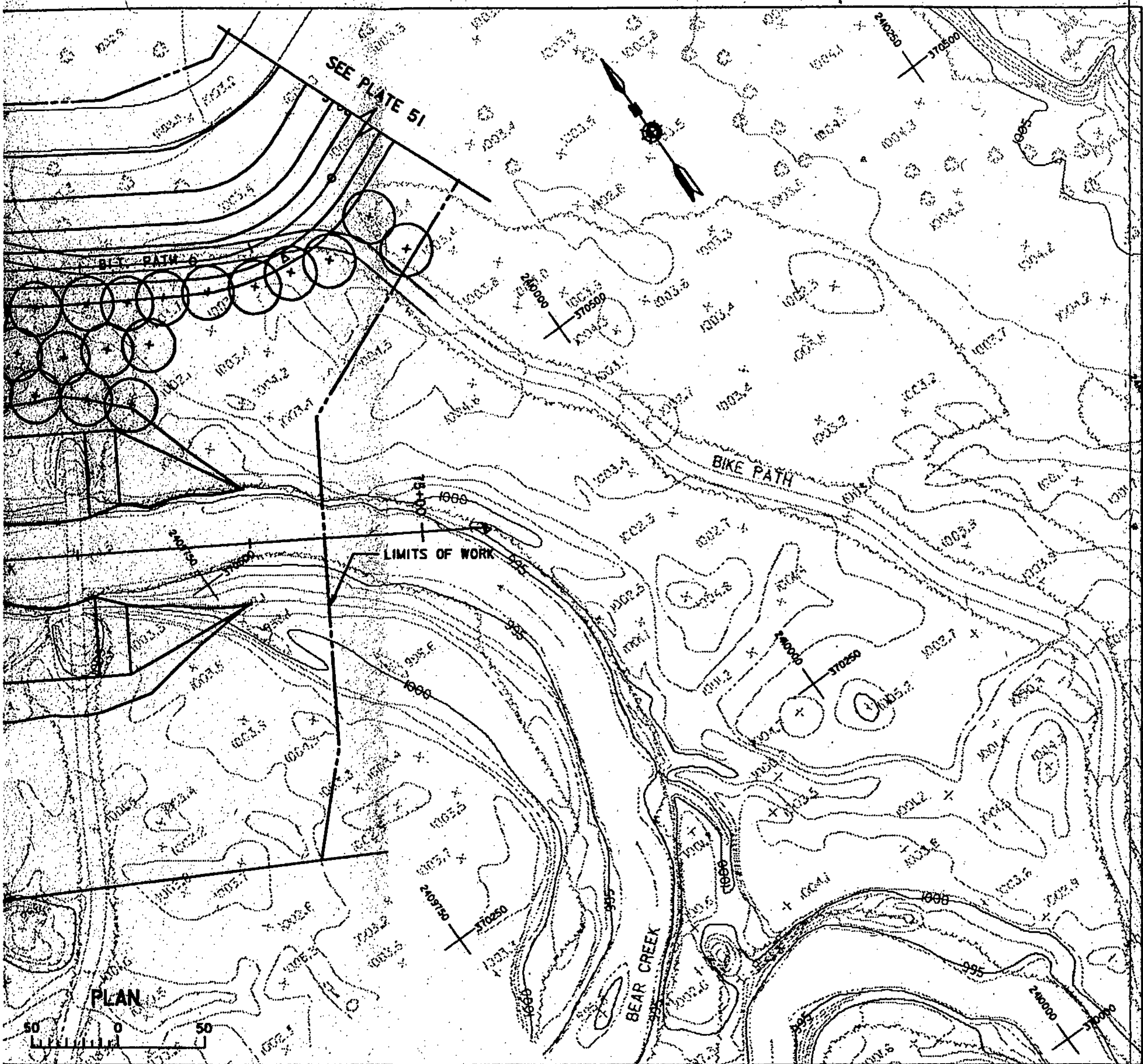
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 60+00 TO 69+00

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
	CHECKED:	LGW
DATE:	MAY 92	

CAD FILE NAME: r4ls7.dgn
SPEC NO:
DRAWING NUMBER: PLATE 49
SHT 49 OF 53



LIMITS OF WORK
PLAY AREAS
BIT. PATH
BIT. PATH
69+00 MATCH WITH PLATE 49
70+00
BRIDGE 3
STA. 70+00
BEAR CREEK
SEE PLATE 52
PLAN
50
0
50



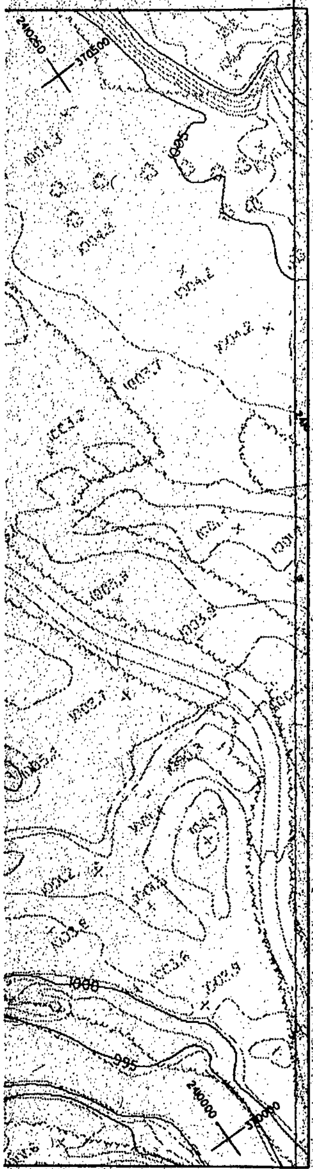
LANDSCAP

LARGE (
SMALL (
EVERGR
LARGE
LIGHTS

SYMBOL	

AE APPROVING OFFICIAL:

ED-D	DESIGNED: KFB/CAS	
	CHECKED: GVF	
	DRAWN: FJB/LGW	
PJP	DESIGNED: LGW	
	CHECKED: LGW	CAD FILE N.
DATE: MAY 92		SPEC NO:



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

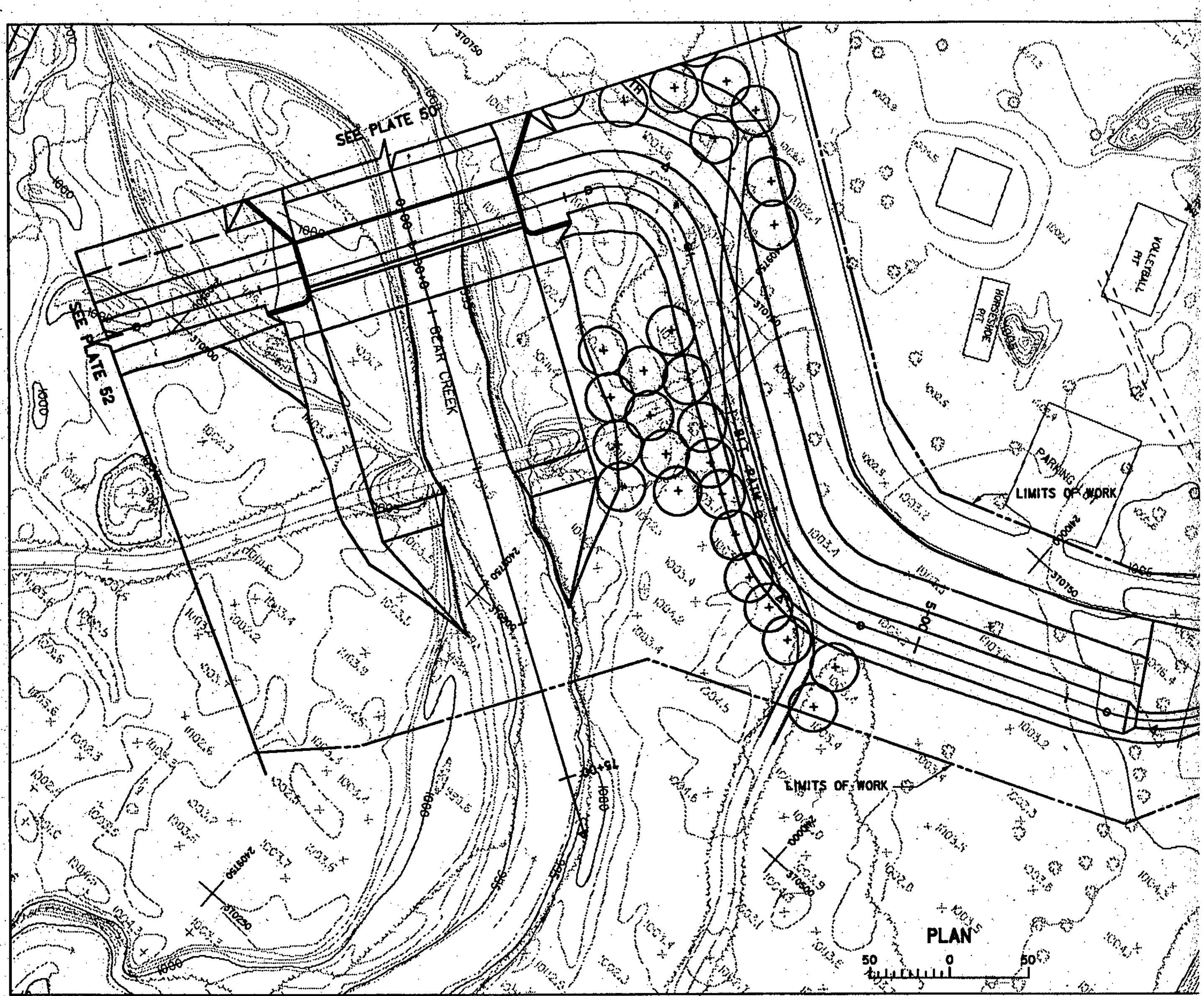
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHNTING PLAN
STATION 69+00 TO 75+35

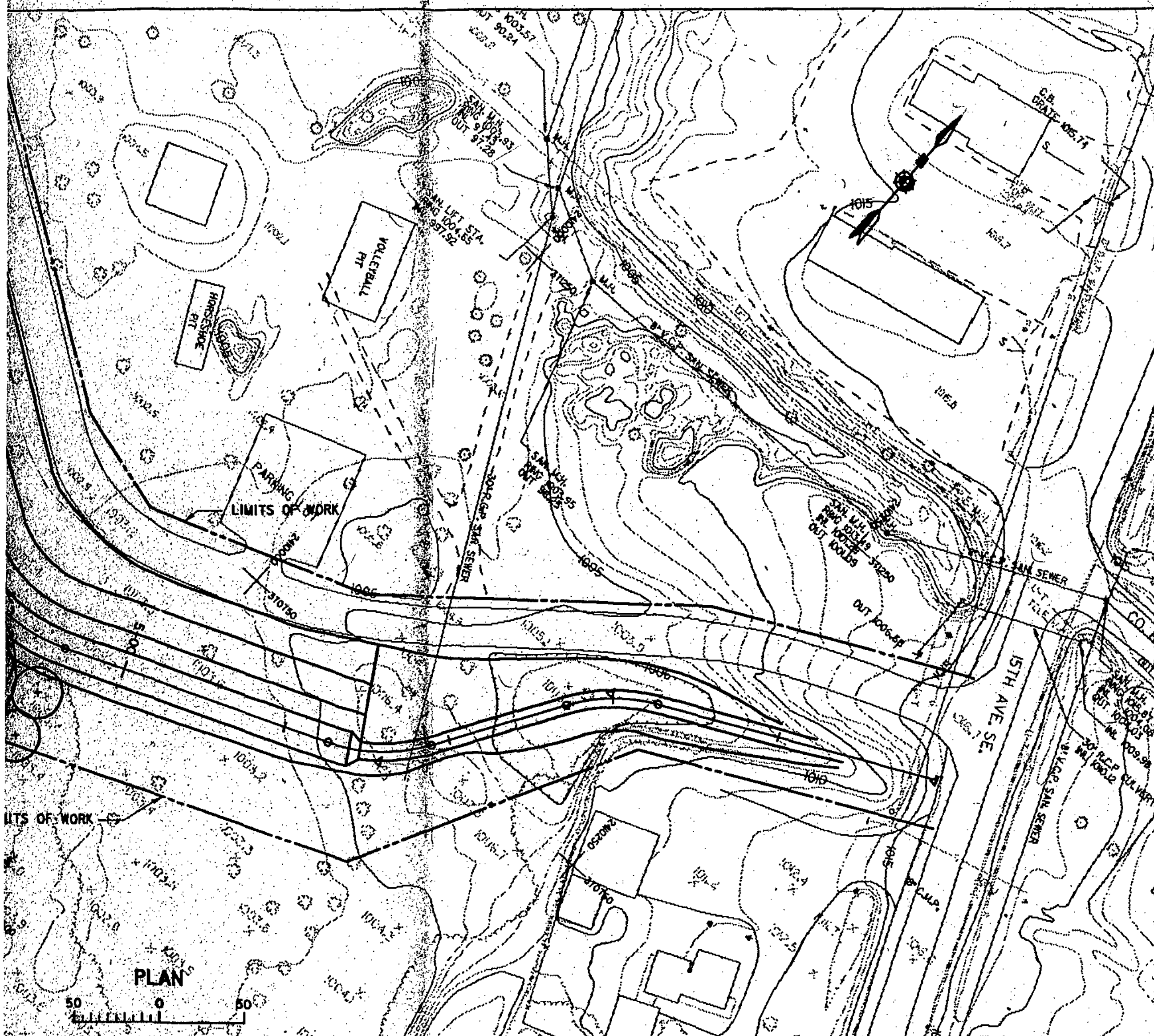
ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
	CHECKED:	LGW
DATE: MAY 92		

CAD FILE NAME: r4ls8.dgn
SPEC NO:
DRAWING NUMBER: PLATE 50
SHT 50 OF 53



SEE PLATE 50
SEE PLATE 52
BEAR CREEK
LIMITS OF WORK
LIMITS OF WORK
PARKING
VOLLEYBALL PIT
HORSESHOE PIT
PLAN
50
0
50

C D E F



LANDS

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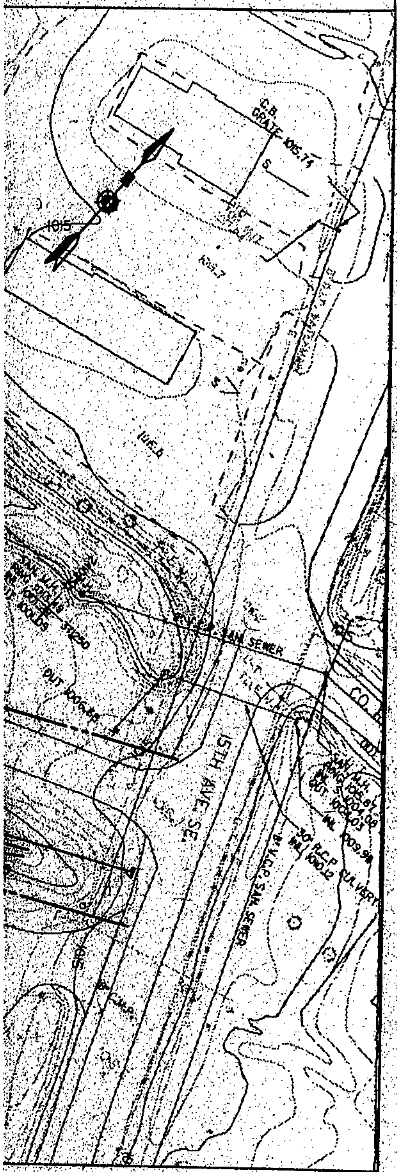
	LI

SYMBOL	
AE APPROVING OFFICIAL:	
ED-D DESIGNED: KFB/CAS	
CHECKED: GVF	
DRAWN: FJB/LGW	
PUP DESIGNED: LGW	
CHECKED: LGW	CAD
DATE: MAY 92	SPEC

C D E F



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
	CHECKED:	LGW

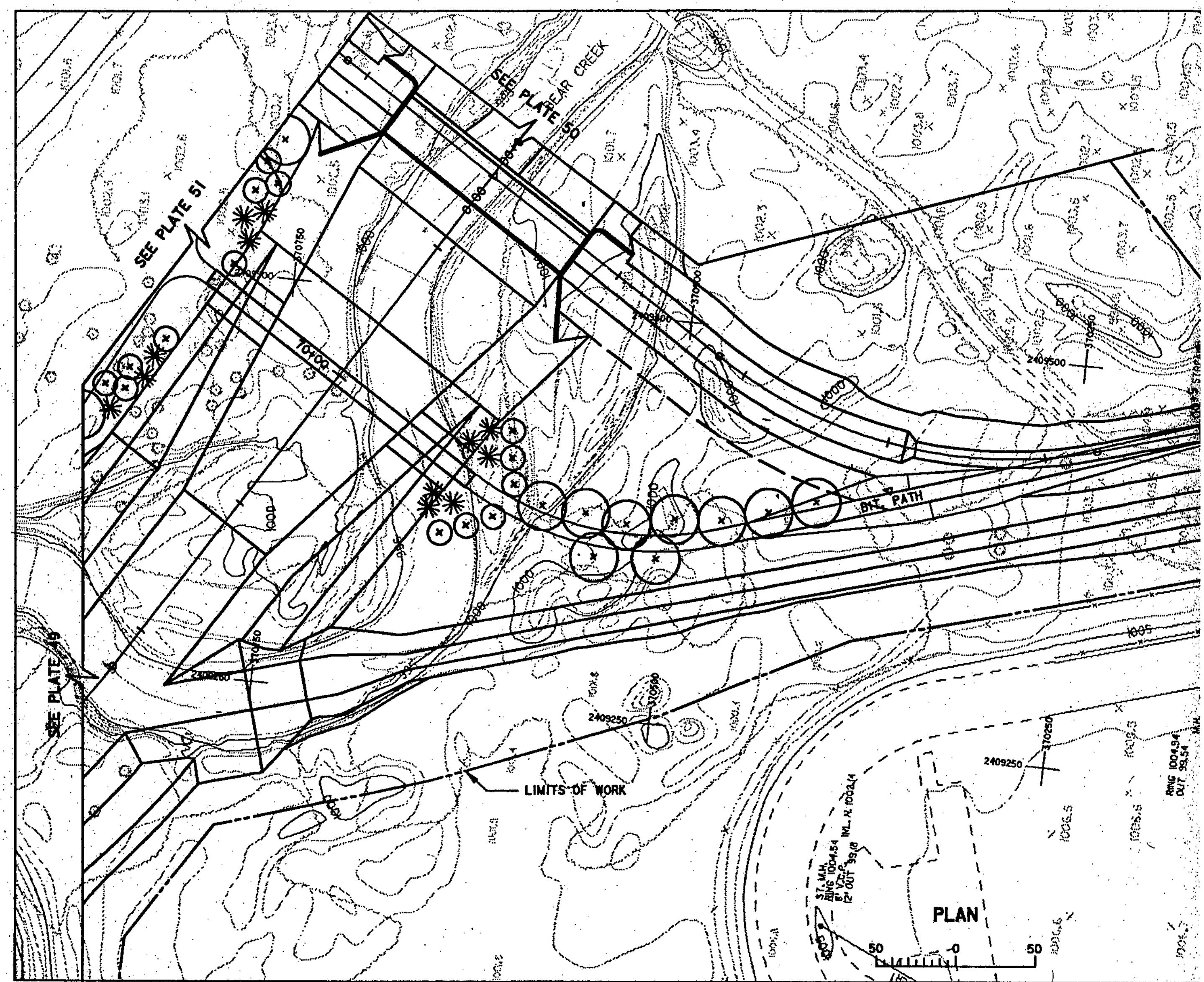
DATE: MAY 92

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 00+71R TO 7+35R

CAD FILE NAME: r4ls9.dgn
SPEC NO:

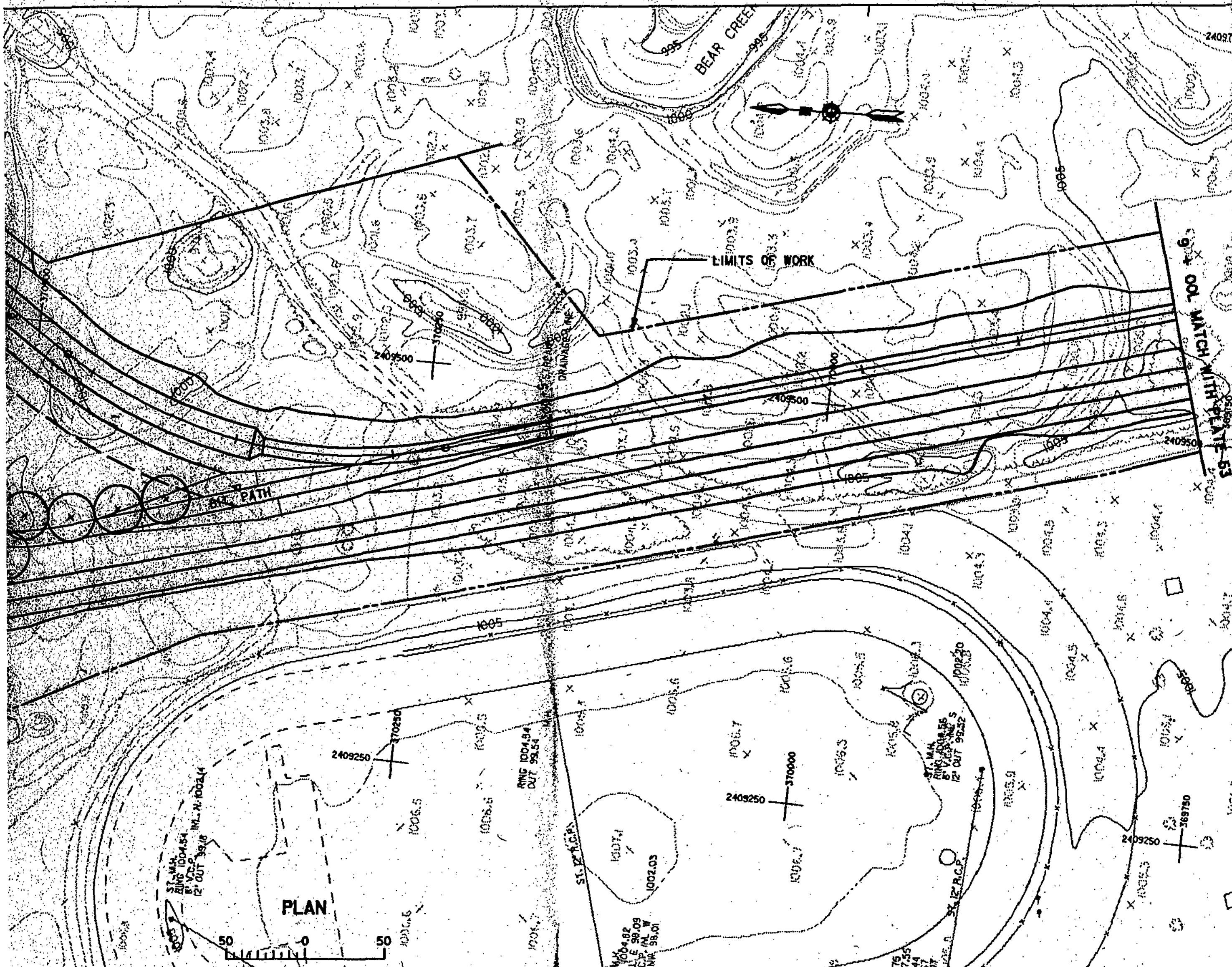
DRAWING NUMBER: **PLATE 51**

SHT 51 OF 53



SEE PLATE 50
BEAR CREEK
SEE PLATE 51
SEE PLATE 49
70+00
BIT. PATH
LIMITS OF WORK
PLAN
50
0
50
2409500
2409250
370750
370500
ST. MH.
RING 1004.54
8" V.C.P.
12" OUT 99.08
INL. N. 1003.4
RING 1004.54
OUT. 99.54

C D E



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DATE

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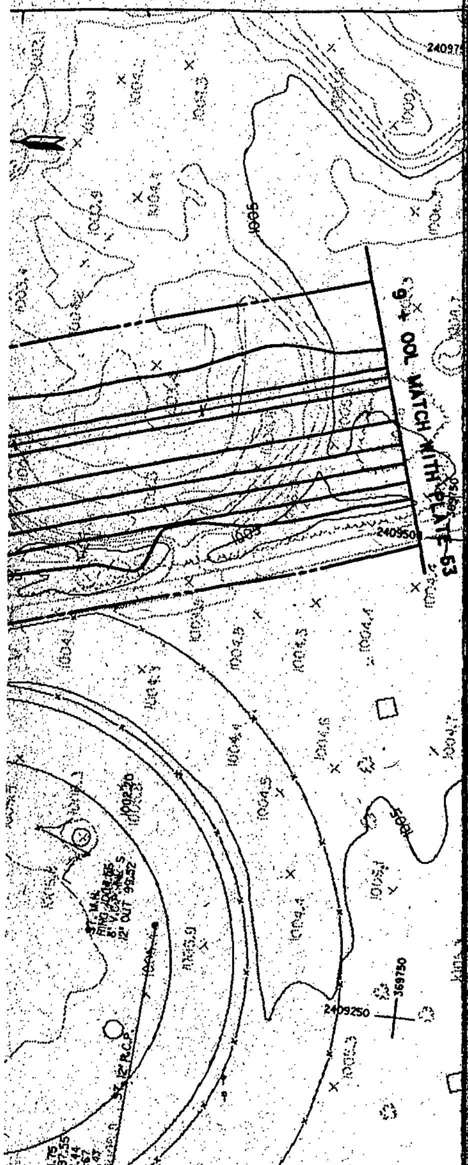


LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

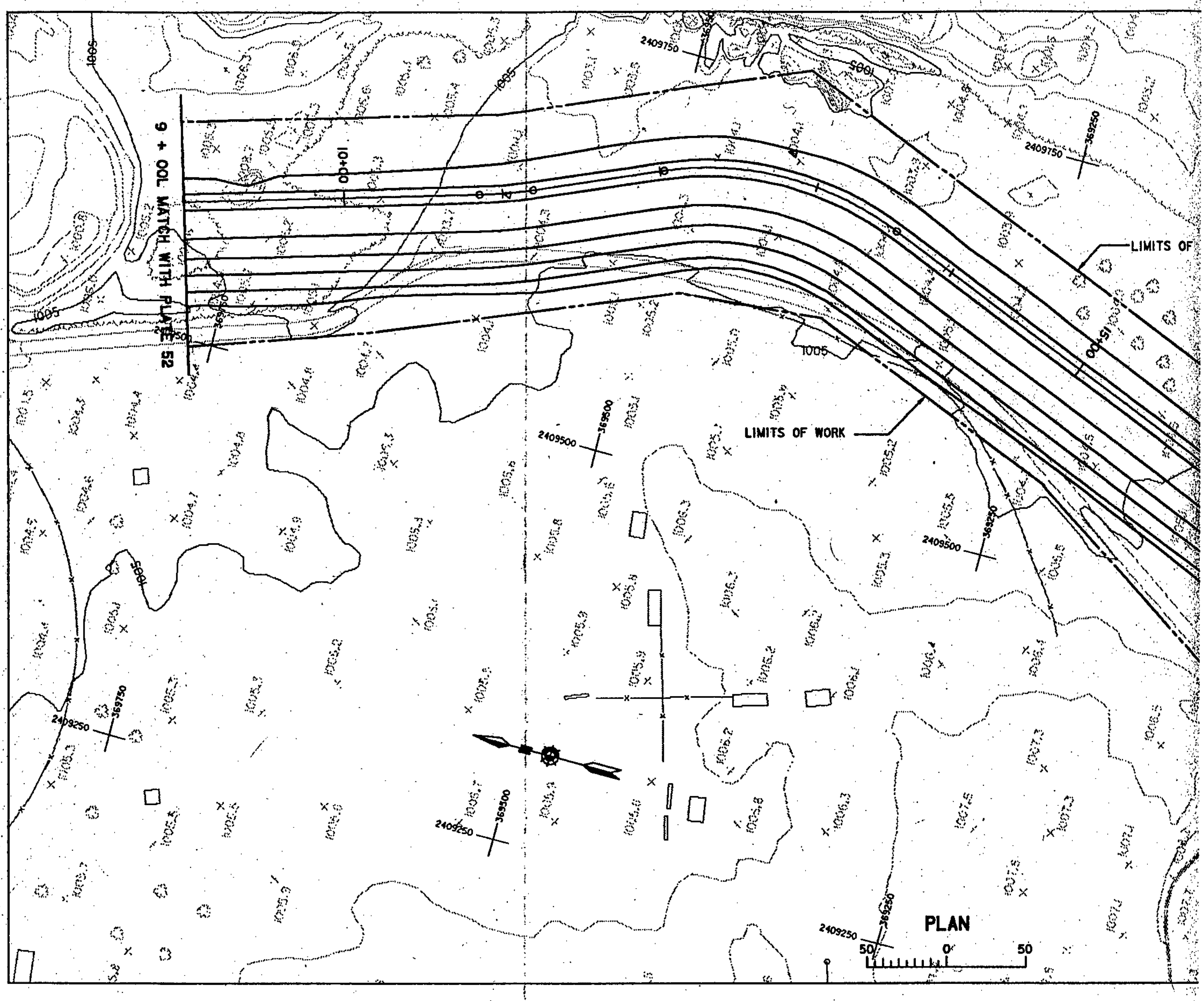
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

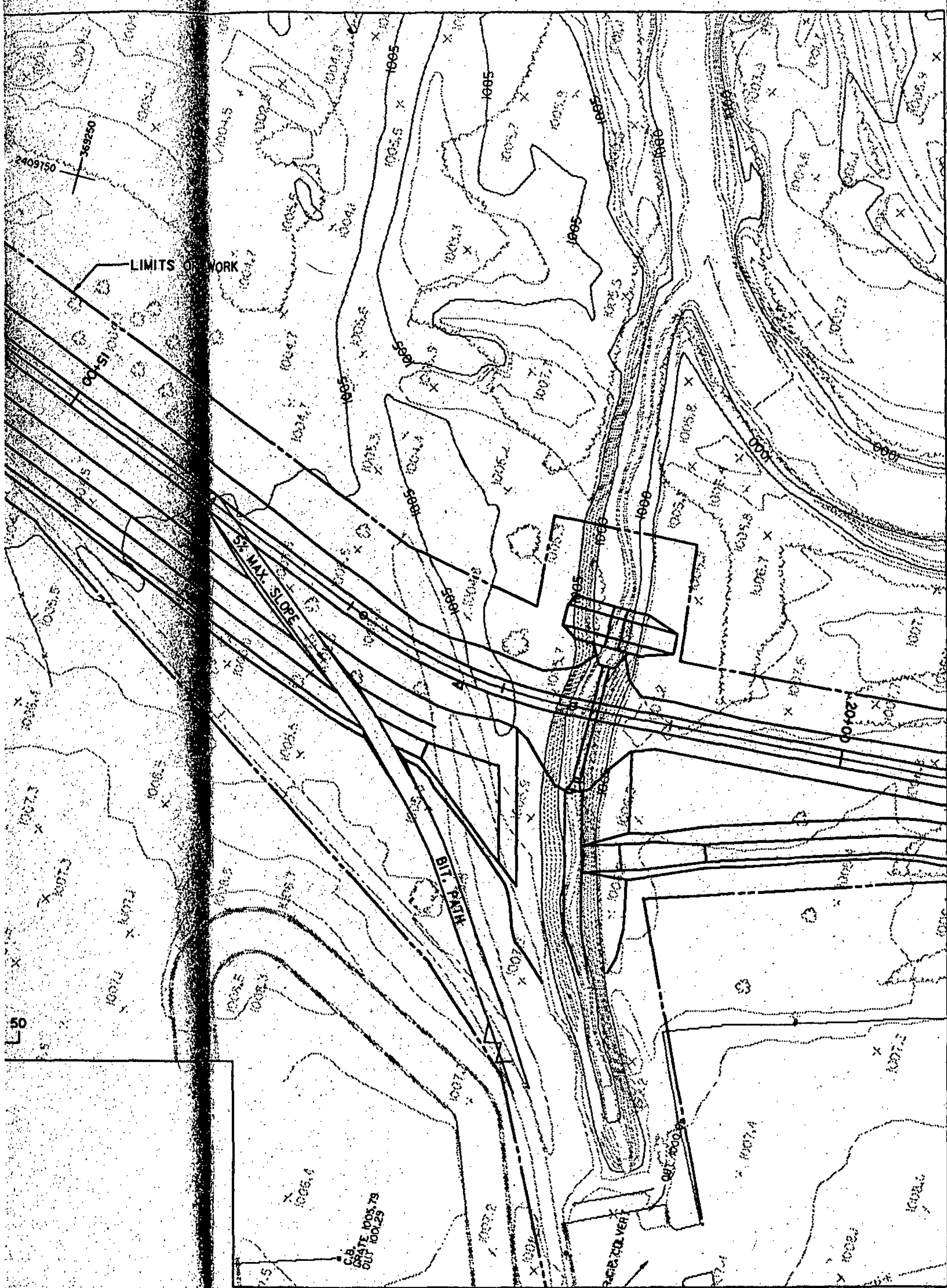
DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 0+00L TO 9+00L

ED-D	DESIGNED:	KFB/CAS
	CHECKED:	GVF
	DRAWN:	FJB/LGW
PLP	DESIGNED:	LGW
	CHECKED:	LGW

DATE: MAY 92
CAD FILE NAME: r4lsl0.dgn
SPEC NO:
DRAWING NUMBER: PLATE 52
SHT 52 OF 53



9 + 00L MATCH WITH PLATE 52
10+00
15+00
LIMITS OF WORK
LIMITS OF
1005
2409750
369750
2409500
369500
2409250
369250
PLAN
50
0
50



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL T
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION

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ST. PA

AE APPROVING OFFICIAL:

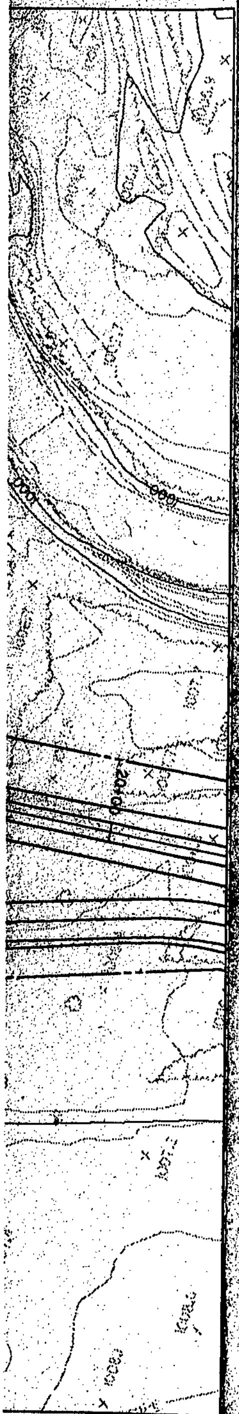
DESIGN MEMORANDUM
FLOOD CONTROL - SOUTH FORK
ROCHESTER, MINNES
STAGE 4-BEAR
LANDSCAPE AND LIGHT
STATION 9+00L TO

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
PUP	CHECKED:	LGW
DATE:	MAY 92	

CAD FILE NAME: r4lsll.dgn

SPEC NO:

DRAWING NUM
PL



LANDSCAPE AND LIGHTING LEGEND

- LARGE CANOPY TREES
- SMALL UNDERSTORY/ORNAMENTAL TREES
- EVERGREEN TREES
- LARGE SHRUBS
- LIGHTS

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

DESIGN MEMORANDUM NO.6
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4-BEAR CREEK
LANDSCAPE AND LIGHTING PLAN
STATION 9+00L TO 20+63L

ED-D	DESIGNED:	KFB/CAS
ED-D	CHECKED:	GVF
ED-D	DRAWN:	FJB/LGW
PUP	DESIGNED:	LGW
PUP	CHECKED:	LGW
	DATE:	MAY 92

CAD FILE NAME: r4lsll.dgn
SPEC NO:
DRAWING NUMBER: PLATE 53
SHT 53 OF 53

APPENDIX A

HYDRAULIC DESIGN

APPENDIX A

HYDRAULIC DESIGN

TABLE OF CONTENTS

PARAGRAPH	DESCRIPTION	PAGE
1	INTRODUCTION	A-1
2-4	DESIGN LEVEL OF PROTECTION	A-1
5-6	GENERAL	A-1
7-16	CHANGES TO THE GDM	A-2
17	DESIGN DISCHARGE AND FREQUENCY	A-3
18-19	CARE OF WATER	A-4
20	CHANNEL DESIGN	A-4
21	STARTING WATER SURFACE ELEVATION	A-4
22-25	CHANNEL	A-5
26-27	BRIDGE MODIFICATIONS	A-6
28	TRANSITIONS	A-7
29	HYDRAULIC STRUCTURE DESIGN	A-8
30	DROP STRUCTURES	A-8
31-32	Alternative Designs	A-8
33-34	Downstream Drop Structure	A-8
35-36	Upstream Drop Structure	A-9
37-41	Drop Structure Design Elements	A-10
42-50	OVERFLOW EMBANKMENTS AND TIE BACK LEVEES	A-11
	SCOUR PROTECTION DESIGN	A-13
51	DESIGN CRITERIA	A-13
52-53	VELOCITIES AND RIPRAP SIZE	A-14
54	RIPRAP GRADATIONS AND BEDDING THICKNESS	A-15
55-63	RIPRAP - TYPE AND LOCATION	A-16
64-65	CHANNEL MAINTENANCE	A-18
	REFERENCES	A-19

TABLES

NUMBER	TITLE	PAGE
A-1	Coincident Discharges with South Fork Zumbro River and Resulting Starting Water Surface Elevations	A-4
A-2	Design Condition Channel Freeboard	A-5
A-3	Bear Creek - Design Channel Slopes	A-5
A-4	Bridge Elevations	A-7
A-5	Channel Transitions	A-7
A-6	Downstream Drop Structure Rating Curves	A-9
A-7	Upstream Drop Structure Weir Elev. and Length	A-9
A-8	Upstream Drop Structure Rating Curves	A-10
A-9	Drop Structure Design Parameters	A-10
A-10	Drop Structure Stilling Basin and Abutment Design	A-10
A-11	Drop Structures Downstream Training Wall Design Elevations	A-11
A-12	Overflow Embankment Design Data	A-12
A-13	Overflow Embankment at Design Capacity	A-12
A-14	Left Bank Tie-back Levee Elevations	A-13
A-15	Scour Protection Design Criteria	A-13
A-16	Channel Velocities and Riprap Design Parameters	A-14
A-17	Riprap Gradations and Bedding Requirements	A-15
A-18	Riprap Size and Location	A-17

PLATES

NUMBER	TITLE
A-1	Alternative Drop Structure

CALCULATIONS

HEC-2 BACK WATER COMPUTATIONS A-20

APPENDIX A
HYDRAULIC DESIGN

INTRODUCTION

1. This appendix presents the hydraulic design of the:

   a. channel
   b. downstream drop structure
   c. upstream drop structure, overflow structure, and tie back levees
   d. scour protection

All elevations presented in this appendix are referenced to National Geodetic Vertical Datum (NGVD) of 1929, all discharges are in cubic feet per second (cfs), and all velocities are in feet per second (fps).

DESIGN LEVEL OF PROTECTION

2. Reducing the scope and level of flood protection from the 170-year level of protection presented in the GDM (reference a), to a 100-year level of protection, was investigated. HEC-2 computer modeling was done to determine if the modification of localized channel reaches and bridge underpasses would reduce the 100-year water surface profile sufficiently to remove the majority of Bear Creek residents from the floodplain.

3. The design discharge for the GDM design is 9,700 cfs, whereas the discharge for the localized modification alternative is 8,500 cfs. These discharges correspond to a recurrence interval of 170 and 100 years respectively and both assume the construction of the three Soil Conservation Service (SCS) reservoirs in the upper reaches of the Bear Creek watershed.

4. The limited modification alternative substantially reduces costs; however, it has several disadvantages compared with the GDM level of protection. The major disadvantages are summarized in the following:

   a. Reduced net benefits.
   b. Stage increases for the SPF flood range from 2 to 6 feet.
   c. Only eliminates the acquisition of two residences.
   d. More residences (about 9) subject to flooding by the 170 year event that are protected by the GDM level of design.
   e. Reduction of the bike trail and recreation facilities.

These disadvantages, coupled with the rapid rising flood stages (as high as 2 feet per hour) and the potentially life threatening situation (four deaths in the flood of 1978), along with local opposition to deviation from the authorized GDM level protection, substantially outweigh the advantages.

GENERAL

5. The Bear Creek channel is to be deepened and widened from its confluence with South Fork Zumbro River to a location 7,000 feet upstream, in the vicinity of Mayo High School. Bottom widths vary from 60 to 140 feet and transitions are provided at each change. Walls will parallel the channel near the 6th Street SE bridge to minimize the channel top width and avoid relocation or modification of the bridge and 9th Avenue SE. A low flow channel with high flow benches is constructed through Slatterly Park and upstream of US Highway 14. Scour protection, consisting of existing bedrock, concrete, riprap, riprap covered with topsoil and grass, and turf, is provided throughout the project with the exception of portions of the channel bottom along the low flow channel which is left unprotected to allow a meandering channel to form (per Fish and Wildlife Service mitigation).

6. Straight drop structures will be located at stations 12+65 and 71+35. The upstream drop structure will have overflow embankments that tie into high ground on both banks with tie-back levees. The design of interior flood control features, including side channel inlets and storm sewer outlets, are presented in Appendix B.

CHANGES TO THE GDM

7. The channel modifications, hydraulic structure design, and scour protection presented in this report is similar to the design presented in the GDM (reference a); however, some changes were made for various design considerations. Each of the changes are discussed in detail in paragraphs 5 through 13; however, the major changes from the GDM can be summarized by the following:

a. Changes to Channel Design:

1. Wider channel bottom between 4th St SE and the downstream drop structure.
2. Side slopes of 1V:3H above the 20-year flow line between 4th St SE and Slatterly Park.
3. Enlarged low flow channel through Slatterly Park.
4. Incorporation of a low flow channel upstream of US Highway 14.
5. Channel realignment through Slatterly Park.
6. Redesign of the channel transitions to accommodate changes in bottom widths and structure sizes.
7. Redesign of the scour protection and the addition of vegetated side slopes.

b. Changes to Hydraulic Structures:

1. Change in location of both drop structures.
2. Removal of the wing walls from the downstream drop structure.
3. Curved abutments substituted for flared abutments on the downstream drop structure.
4. Redesign of the upstream drop structure and overflow embankments.
5. Lower and longer overflow embankments.
6. Lower tie-back levees significantly reduced in length.

8. The channel bottom width between 4th St. SE and the downstream drop structure was increased by 20 feet (from 60 to 80-feet) to reduce velocities in the channel bend approaching 4th St SE and to eliminate the channel contraction downstream of the drop structure.

9. Between 4th St SE and the downstream end of Slatterly Park there is a break in the 1V:2.5H side slope at an elevation 8.5 feet above the channel invert to provide a mow-able 1V:3H slope on which seeded topsoil over riprap is used. The 8.5 foot depth corresponds to approximately the 5-percent chance of exceedence (20-year recurrence) flow line (reference c).

10. The low flow channel through Slatterly Park was enlarged to a capacity capable of conveying the 5-year flood event (20-percent chance of exceedence). This was done by increasing the bottom width by 15 feet (from 50 to 65-feet) and raising the high flow bench elevation by 2 feet (from a depth of 5 to 7-feet). The high flow bench width was reduced from 30 feet to 22.5 feet. The purpose of increasing the low flow capacity is to reduce velocities in the high flow area to allow establishment of grass stand on the high flow bench and side slopes above the high flow bench. A low flow channel was also incorporated into the channel upstream of US Highway 14 to reduce the possibility of sedimentation occurring in the channel downstream of the drop structure and as a mitigation measure with the Fish and Wildlife Services.

11. The channel alignment was changed through Slatterly Park to avoid removal of existing structures. The channel slopes remain unchanged from the GDM; however, the realignment of the channel and the relocation of the drop structures caused minor changes to the channel inverts and the channel stationing.

12. Changes to the channel configuration and the redesign of the upstream drop structure resulted in changes to the transitions at the drop structures and the 4th St SE and US Highway 14 bridges. These changes are presented in detail in the TRANSITION DESIGN portion of the CHANNEL DESIGN section.

13. Scour protection throughout the project was re-analyzed due to changes in channel configuration, redesign of the upstream drop structure and overflow structure, concern for vandalism, and the addition of vegetated side slopes. The right bank side slope downstream of 4th Street SE will be protected by interlocking concrete slope protection to match the adjoining section of the completed channel modifications. Side slopes downstream of Slatterly Park will be grass covered above the 5-percent chance of exceedence flow line (reference c). High flow benches and side slopes, as well as the overflow embankments, are also grass covered. A detailed discussion of the changes to the scour protection are presented in the SCOUR PROTECTION portion of this Appendix.

14. The downstream drop structure was moved about 200 feet downstream (from station 15+00 to 13+00). This was to avoid construction difficulties associated with the structure's close proximity to a convalescent home and to reduce the amount of rock excavation required. The wing walls were removed (reference e) for economic reasons and curved abutments replaced the flared abutments to be in accordance with model test recommendations (reference f).

15. The upstream drop structure, located upstream of US Highway 14, was moved about 400 feet upstream to eliminate the following two problems associated with the GDM location:

a. The right bank levee extended through Bear Creek Park and tied into private land.
b. The redesign of the drop structure required longer overflow embankments which would encroach on the Mayo High School grounds located on the left bank.

Flared wing walls were added (reference g) to the drop structure to retain the overflow embankments near the structure. The weir was increased in length and reduced in height to match upstream existing condition stages for events up to the design event.

16. The overflow embankment was increased in length and reduced in height to produce a reduced upstream water surface profile for flows exceeding the design event. This allowed the tie-back levees to be reduced in height and thereby, significantly reduced the length. The overflow embankment gabions were replaced with top soil over riprap (reference h) to decrease cost. The redesign of these structures is presented in detail in the HYDRAULIC STRUCTURE DESIGN portion of this Appendix.

DESIGN DISCHARGE AND FREQUENCY

17. The Rochester flood control project consists of channel modifications within the city, proposed by the Corps of Engineers, and seven small reservoirs that are being constructed by the Soil Conservation Service (SCS). The combination of the channel work and reservoirs is intended to provide protection for the same flood discharge used in the Phase 1 and Phase 2 General Design Memorandums. At the time of the Phase 1 report, these discharges were estimated to be the 1-percent chance of exceedence (100-year recurrence interval). Re-analysis of the frequency curves for the Phase 2 report resulted in the design discharge of 9,700 cfs having a 0.59 percent exceedence probability (about 170-year recurrence interval).

CARE OF WATER

18. Care of water is concerned with how flow in the river is handled during the construction period. There are two areas of concern that the care of water plan has to address:

a. Protection of the construction activity from flood flows.
b. Assurance that the temporary measures used to protect the construction activity do not increase the potential for significant flood damages to areas outside the construction zone.

19. The care of water plan for the channel work will not require any major cofferdams or diversions. Formulation of the cofferdam and diversion requirements for the drop structures will be accomplished during the development of Plans and Specifications.

CHANNEL DESIGN

20. The channel design is basically the same as that presented in the GDM with the exception of the changes discussed in the INTRODUCTION section. The HEC-2 model parameters, for example Manning's "n" values, expansion and contraction coefficients, did not change.

STARTING WATER SURFACE ELEVATION

21. The starting water surface elevations do not assume concurrent peak discharges on the South Fork of the Zumbro River and Bear Creek. For each event, flow lines using elevations representing the peak Zumbro discharge and the coincident Bear Creek discharge were compared with coincident stages on the Zumbro with peak discharges on Bear Creek. The higher of the two profiles was assumed to the point of intersection, where Bear Creek peak discharges were then used to determine the flow lines upstream of that point. Table A-1 shows the coincident discharges and resulting starting water surface elevations. The HEC-2 input and output files, showing stages for a wide range of storm events, are included at the end of this Appendix following the REFERENCES section.

TABLE A-1
Coincident Discharges with South Fork Zumbro River
and Resulting Starting Water Surface Elevations

Event	Time (hrs)	Bear Ck Discharge	S. Fork Discharge	Combined Discharge	Water Elevation
5-yr	18	3,400	1,630	5,030	977.9
10-yr	18	4,300	2,000	6,300	978.8
25-yr	18	5,900	2,540	8,440	980.2
50-yr	17.5	7,200	2,850	10,050	981.0
100-yr	18	8,500	3,450	11,950	982.0
Design	18	9,700	4,000	13,700	983.0
SPF	19	22,000	26,030	48,030	994.5
5-yr	30	500	5,800	6,300	978.9
10-yr	28	830	7,400	8,230	980.0
25-yr	28	1,140	9,800	10,940	981.5
50-yr	27	1,700	12,000	13,700	983.0
100-yr	27	2,100	14,200	16,300	984.1
Design	26	3,000	16,800	19,800	985.6
SPF	25	12,000	48,000	60,000	997.5

CHANNEL

22. The points of low freeboard control channel design. Freeboard, for this report, is defined as the vertical distance between the design flood profile and elevation where damages begin. A Manning's "n" value of 0.035 was used to determine the water surface profile. In accordance with EM 1110-2-1601 (reference c), freeboard of about 2.5 feet is maintained where the design discharge is contained in the channel. Overflow is allowed in the park areas but the design water surface profile is 2 feet or more below the damage elevation. Table A-2 shows the damage elevation, based on structure elevations, and the design water surface elevations.

TABLE A-2
Design Condition Channel Freeboard

Section	Station	Damage Elevation	Invert Elevation	Design Water Surface Elev.
1	3+25	989.0	971.7	985.6
2	5+60	987.8	972.2	985.6
3	10+00	988.2	973.1	985.7
4	12+40	992.2	973.5	985.7
5	15+10	993.8	978.4	990.7
6	19+10	994.0	979.6	991.3
7	22+25	994.3	980.6	992.1
8	24+20	997.0	981.2	992.6
9	28+20	998.2	982.4	993.8
10	32+00	998.1	983.5	995.2
11	35+65	1000.5	984.4	996.0
12	38+90	1003.2	985.0	996.6
13	40+40	1002.8	985.3	996.9
14	43+05	1001.2	985.8	997.4
15	47+80	1002.5	986.7	998.3
16	50+85	1003.5	987.3	998.9
17	51+90	1003.5	987.4	999.1
18	55+30	1005.0	988.1	999.8
19	60+35	1005.0	989.0	1000.7
20	64+15	1003.9	989.6	1001.4
21	69+10	1005.0	990.5	1002.4

23. As discussed in the introduction, realignment of the channel and relocation of the drop structures caused minor changes to the channel inverts and the channel stationing. Table A-3 shows the channel slopes and corresponding channel inverts.

TABLE A-3
Bear Creek - Design Channel Slopes

Location	Station	Slope ft/ft	Elevation
South Fork Zumbro River	2+50		971.5
to		.002	
D/S End of D/S Drop Structure	12+65		973.6
U/S End of D/S Drop Structure	13+00		977.8
to		.003	
D/S Area of Slatterly Park	33+35		983.9
to		.002	
D/S End of U/S Drop Structure	71+60		991.2

24. The channel curve radii are 2.5 times the channel width or greater with the exception of the curved approach to 4th St SE. Because of the nature of the channel alignment through the urban area, a radius of 250 feet was determined to be the most appropriate. Although this radius is about 1.6 times the channel width, it greatly improves the approach to 4th St SE over existing conditions. Super-elevation caused by the transverse water-surface elevation around the curve was determined to be 2.0 feet using,

$$\Delta y = C \frac{V^2 W}{gr}$$

where,

Δy = rise in water surface
C = super elevation coefficient (0.5)
V = mean channel velocity
W = channel width
g = acceleration of gravity
r = radius of channel

This 2 foot rise in the water surface produces an elevation of 985.7 feet NGVD which is 4 feet below the top of bank on the outside bend.

25. The channel is designed for subcritical flow except at the drop structures. The stability of channel flow was investigated using the following established criteria (reference c).

Tranquil flow $d > 1.1d_c$ or $Fr < 0.86$

Froude Numbers along the channel length vary from 0.3 to 0.5 for the design condition, thus avoiding unstable flow and excessive wave action.

BRIDGE MODIFICATIONS

26. The channel design was made to provide as much bridge clearance as economically possible. No bridge replacements are needed. The Minnesota Department of Transportation (Mn/DOT) does however, plan to replace the US Highway 14 west bound bridge in 1994-1995. The proposed Mn/DOT design was incorporated into the HEC-2 computer model.

27. Bridge clearance for the bridges is defined as the vertical distance between the design water surface elevation and the low chord elevation of the bridge. The three pedestrian bridges will have 3 feet of clearance at the channel centerline and a minimum of 2.5 feet at top of bank. Clearance for the three street and highway bridges varies from 1 foot, at 4th St SE, to 3 feet at US Highway 14. Because of the bridges and drop structures located upstream of 4th St SE, plugging of the bridge by ice or debris is unlikely. The street approaches to the 4th St SE bridge are lower than the bridge deck and are overtopped before the bridge. Table A-4 shows the bridge low chord, design water surface, and channel invert elevations.

TABLE A-4
Bridge Elevations

Bridge	Design Water Surface	Low Chord	Design Invert	Existing Invert
4th St SE	985.6	986.7	972.3 - 972.4	975.7
6th St SE	992.3	994.2	980.8 - 981.0	983.6
US Highway 14	1001.1	1004.1	989.2 - 989.4	988.5

TRANSITIONS

28. Channel transitions are located upstream and downstream of the 4th St SE and US Highway 14 bridges. Transitions are also located at the drop structures and the change to compound channel at Slatterly Park. The transitions are designed in accordance with EM 1110-2-1601 (reference c) to accomplish the necessary change in channel bottom width with as little flow disturbance as is consistent with economy. Water surface profiles were determined by step computations with less than 20 percent change in velocity between steps. All transitions flare at a rate of 1-horizontal to 6-longitudinal or greater. This allowed the maximum change in flow line to be less than 6-degrees. Table A-5 shows the transition locations and lengths. Lengths are measured along the channel center line.

TABLE A-5
Channel Transitions

Transition Location	Station	Bottom Width (ft)	Transition Length (ft)
	4+60	80	
Downstream face 4th St. SE	5+90	110	130
Upstream face 4th St. SE	6+65	110	215
	8+80	80	
	12+15	80	
Downstream end Drop Structure	12+65	75	50
Upstream end Drop Structure	13+00	75	50
	13+50	60	
	33+35	60/102*	
Downstream end Slatterly Park			370
	37+05	65/152*	
	60+35	65/152*	
Downstream face US Highway 14	61+70	110	135
Upstream face US Highway 14	62+80	110	135
	64+15	65/152*	
	68+85	65/152*	
End of High Flow Bench	70+20	110	135
	71+10	140	90
Downstream end Drop Structure	71+35	140	25

* Width of channel at high flow bench.

HYDRAULIC STRUCTURE DESIGN

29. The locations for the two proposed drop structures on Bear Creek were moved from the locations shown in the GDM. The reasons for this and other changes are discussed in the CHANGES TO THE GDM portion of the INTRODUCTION section, paragraphs 14,15, and 16.

DROP STRUCTURES

30. The drop structures are CIT (California Institute of Technology) type design. Design criteria was taken from HDC Chart 623 and EM 1110-2-1601 (references i and c respectively). As a safety feature, fencing near the structures is provided. Concern for the reverse roller produced by the drop structures is minimal because of the fast rising and falling flood hydrographs; however, alternative designs incorporating a stepped weir are being investigated for plans and specifications.

Alternative Designs

31. Alternative drop structure designs incorporating a stepped weir are being investigated. Although a stepped weir design may be more costly, it would provide advantages over the CIT type design and therefore, merits further investigation. These advantages include the following:

The stepped structure would,

a. reduce the drop height and thus provide a physical safety feature.
b. reduce the reverse roller affects.
c. serve as a mitigation measure for the Fish and Wildlife Services who have expressed concern for fish migration.
d. be more acceptable to the local concerns.

32. Preliminary designs, following drop structure design guidance provided by Waterways Experiment Station (WES) model studies of the Santa Anna River (reference k), are shown on Plate A-1. Conversations with WES indicate that a model study will not be required should this alternative be employed.

Downstream Drop Structure

33. The purpose of the downstream drop structure is to control channel velocities (not to exceed 12-fps upstream) by conveying flows from a higher elevation to lower elevation and dissipate energy in the process. The structure is capable of passing flows up to the design event with 3 feet of freeboard. It is located midway between the bowling alley and convalescent home between Stations 12+65 and 13+00.

34. The weir elevation of the downstream drop structure is the same as the upstream channel invert. A weir length of 75 feet was determined to adequately meet upstream velocity and stage requirements. Table A-6 shows the resulting drop structure rating curves compared with existing conditions.

TABLE A-6
Downstream Drop Structure
Rating Curves

Event	Discharge	Head on Weir (ft)	Tail-Water Elev.	Head-Water Elev.	Existing Condition Elevation
5-yr	3,400	6.1	979.6	983.9	985.5
10-yr	4,300	7.1	980.5	984.9	986.9
25-yr	5,900	8.8	981.9	986.6	988.0
50-yr	7,200	10.1	982.9	987.9	988.8
100-yr	8,500	11.3	983.8	989.1	989.6
Design	9,700	12.3	984.7	990.1	990.4
SPF	22,000	17.2	994.9	995.0	995.0

Upstream Drop Structure

35. The upstream drop structure is located at the upstream end of the channel modification (station 71+35). Its purpose is to prevent degradation of the upstream channel. This was accomplished by sizing the weir such that upstream channel velocities do not exceed existing conditions for the 2-year through the design event. Using existing condition stages and velocities, the two design variables, length and elevation, were determined by trial and error for the 2-year and design events. A 5 foot by 5 foot low flow notch is located at the center of the weir to prevent ponding of water behind the weir for low flow conditions. Because of the comparatively small amount of flow through the low flow notch and because of the possibility of plugging, the low flow notch was not considered in the weir computations. The results are presented in Table A-7.

TABLE A-7
Upstream Drop Structure
Weir Elevation and Length

Trial	Event	Discharge	Weir Elevation	Headwater Elevation	Head on Weir (ft)	Required Weir Length (ft)
#1	2-yr	2400	999.0	1001.4	2.4	215
	Design	9700	999.0	1006.3	7.3	164
#2	2-yr	2400	998.0	1001.4	3.4	127
	Design	9700	998.0	1006.3	8.3	135
#3	2-yr	2400	998.2	1001.4	3.2	140
	Design	9700	998.2	1006.3	8.1	140

36. The with project headwater stages between the design and SPF events are lower than existing condition stages. The flow lines do however, merge with existing conditions at the upstream end of the left bank tie-back levee. Table A-8 shows the headwater and tailwater rating curves compared with existing conditions. For the SPF event, there is little difference between existing condition stages and with project stages. This is because the tie-back levees are over topped and the high tailwater conditions reduce the weir coefficients. This is discussed further in the OVERFLOW EMBANKMENTS AND TIE BACK LEVEES portion of this section.

TABLE A-8
Upstream Drop Structure
Rating Curves

Event	Discharge	Existing Condition Elevation	Head on Weir (ft)	Head-Water Elev.	Tail-Water Elev.
2-yr	2400	1001.4	3.2	1001.4	997.2
5-yr	3400	1002.3	4.0	1002.2	998.4
10-yr	4300	1003.0	4.7	1002.9	999.5
25-yr	5900	1004.0	5.8	1004.0	1000.7
50-yr	7200	1004.8	6.7	1004.9	1001.6
100-yr	8500	1005.6	7.4	1005.6	1002.4
Design	9700	1006.3	8.1	1006.3	1003.2
500-yr	12000	1008.2	8.8	1007.0	1004.2
2500-yr	17500	1009.4	10.3	1008.5	1007.5
SPF	22000	1010.3	11.9	1010.1	1009.1

Drop Structure Design Elements

37. Tables A-9 and A-10 show the design parameters used to determined the drop structure design elements.

TABLE A-9
Drop Structures
Design Parameters

Drop Structure Location	Design Discharge	Downstream Invert	Weir Elevation	Weir Length (ft)	Weir Coeff. C	Weir Head (ft)	Critical Depth (ft)
D/S	9700	973.6	977.8	75	3.0	12.3	8.0
U/S	9700	991.4	998.2	140	3.0	8.1	5.3

TABLE A-10
Drop Structures
Stilling Basin and Abutment Designs

Drop Structure Location	Drop Height feet	h/d_c	h'/d_c	End Sill Height feet	$\frac{L_B}{(hd_c)^{.5}}$	Basin Length feet	Abutment Radius of Curvature
D/S	4.2	0.52	0.22	1.8	6.0	35	4.8'
U/S	6.8	1.30	0.33	1.8	4.8	29	3.2'

38. The radius of curvature for the drop structure abutment, listed in Table A-10 is a minimum requirement. The radius may be greater than this.

39. The elevation of the abutment walls are based on the minimum requirement that they be 1.5 d_c above the weir crest. For the downstream structure this would be elevation 990.9 feet NGVD; however, elevation 993.0 feet NGVD was selected for the abutment wall and breast wall to provide additional freeboard and to match the top of bank elevation. This is about 3 feet above the design headwater stage. The upstream structure has overflow embankments on each side with a crest elevation of 1006.5 feet NGVD. Because of this, an abutment elevation was selected such that it projects 1 foot above the overflow embankments to guide flow towards the drop structure and prevent scour at the juncture of the drop structure and overflow embankment.

40. The downstream training wall heights are based on tail water elevations plus freeboard. Table A-11 shows the computed tailwater elevations, freeboard, and resulting elevation for the downstream training walls.

TABLE A-11
Drop Structures
Downstream Training Wall Design Elevations

Drop Structure Location	Design Discharge	Tail-Water	Channel Invert	Free-board feet	Training Wall	Elevation @ 1.67d_c & 1.25d_c
D/S	9700	984.7	973.6	3.3	988.0	986.7/983.6
U/S	9700	1003.0	991.4	2.0	1005.0	1000.3/998.0

41. There are no wing walls on the downstream drop structure (reference f); however, flared wing walls are provided on the upstream drop structure to retain earth near the overflow embankments. The walls flare at a rate of 1-horizontal to 1.5-longitudinal (reference e).

OVERFLOW EMBANKMENTS AND TIE BACK LEVEES

42. Overflow embankments are located on each side of the upstream drop structure. Flows in excess of the design event pass over these embankments. They are constructed with a crest elevation of 1006.5 feet NGVD, thus maintaining design flows through the drop structure.

43. Levees are constructed to an elevation of 1008.5 feet NGVD at the ends of the embankment and tie the overflow embankments into high ground on the left and right banks. The right bank levee has a constant elevation of 1008.5 feet NGVD, where as the left bank levee progressively increases to an elevation of 1010.1 feet NGVD where it ties into high ground about 2400 feet upstream of the drop structure. The tie-back levees provide over 2-ft of freeboard for the design event and the levee system has a capacity of 17,500 cfs which corresponds to the 0.04-percent chance storm (2500-year recurrence). Freeboard analysis of the tie-back levees is presented later in this section.

44. The overflow embankments and tie back levees span the creek's floodplain and have the appearance of a dam. Therefore, the hazards that would be associated with overtopping were evaluated and compared to the latest dam safety criteria. This structure does not present any significant hazard to downstream areas. The first overflow will take place at the overflow embankments that will have riprap protection designed to protect against failure. By the time the unprotected tie back levees are overtopped, the tailwater will have risen to within 1.3 feet of the head water. This small head differential poses no additional threat to downstream areas that would already have significant flooding.

45. The overflow embankments were designed using WES Technical Report No. 2-650 (reference h) for nonaccess type embankments. For the capacity discharge of 17,500 cfs, 11,600 cfs passes through the drop structure and 5,900 cfs passes over the overflow embankments. Design information is shown in Tables A-12 and A-13.

TABLE A-12
Overflow Embankment Design Data

Discharge cfs	Tailwater Elevation	Headwater Elevation	Embankment Dimensions: Crest Elev.	Height (ft) Low/High	Crest Width (ft)
5900	1007.2	1008.5	1006.5	3/5	20

TABLE A-13
Overflow Embankment at Design Capacity

Depth TW above Crest (ft)	Gross Head on Crest (ft)	Flow Condition (Plate 40)	Weir Coefficient (Plate 42)	Overflow Discharge	Effective Overflow Length feet
0.7	2.0	Free	2.98	5900	700

46. The effective embankment length of 700 feet is divided disproportionately to the left and right of the drop structure. Because of the embankments close proximity to the Mayo High School, 225 feet of the embankment is to the left of the drop structure and the remaining 475 feet is to the right.

47. The embankment has side slopes of IV:3H upstream and IV:4H downstream with a crest width of 20 feet. It will be constructed of riprap covered with seeded top soil. The crest will be covered with topsoil to the design elevation of 1006.5 ft NGVD.

48. From the stability charts shown on Plate 49 of the WES report (reference h), stone with the following gradation is suitable:

Stable Stone Gradation

d_{100}	W_{100}	W_{50}	W_{15}
16"	200	20	5

Therefore, the overflow embankment will be constructed of 18-inch Type B riprap with 9-inches of bedding material. The bedding gradation is given Appendix C.

Type B Riprap Gradation

Percent Lighter by Weight (lbs)

	100		50		15	
d_{100}	Max	Min	Max	Min	Max	Min
18"	292	119	86	58	43	18

In the event the top soil is stripped off, the discharge over the embankment will increase accordingly due to the change in available head.

49. Freeboard analysis of the left bank tie-back levee was performed under the following assumptions:

a. Mannings's "n" values: doubled from 0.033 to 0.066 for the channel and from 0.09 to 0.18 for the overbanks
b. Weir coefficient: decreased from 3.0 to 2.5
c. Design discharge: increased by 15%, from 9,700 cfs to 11,155 cfs (this increase is greater than the upper confidence limit)

The water surface profile produced by these assumptions is referred to as the "nCQ" flow line. It is highly unlikely that all of the worst case factors would apply at the same time and thereby assures a conservative design. Table A-14 shows the design flow line and the left bank tie-back levee elevations.

TABLE A-14
Left Bank Tie-back Levee Elevations

Left Bank Location	Levee Station	Design Water Surface	"nCQ" Flow line	Tie-Back Levee Levee
At Overflow Structure	4+00	1006.3	1007.4	1008.5
Upstream of Track Field	9+00	1006.8	1008.3	1008.9
Inlet from Church Area	18+50	1007.4	1009.4	1009.5
Tie Back Point	28+70	1008.0	1010.1	1010.1

50. Overtopping would first occur at the upstream end in an area with a parking lot and open land and would cause no flooding of buildings or residences. Based on this sensitivity analysis and the fact that overtopping causes no threat to human life, two feet of freeboard for the tie-back levee is adequate.

SCOUR PROTECTION DESIGN

DESIGN CRITERIA

51. The scour protection design for this project is broken into three categories; channel, bridges and drop structures. The design criteria for each is presented in Table A-15.

TABLE A-15
Scour Protection Design Criteria

Protection Provided For	Design Criteria		
Channel			
High Flow	EM 1110-2-1601,	July 91	Appendix C
	ETL 1110-2- 120,	May 91	Enclosure 1
Main Channel	EM 1110-2-1601,	July 91	Plates B 33-40
	ETL 1110-2- 120,	May 71	Enclosure 1
Bridges	EM 1110-2-1601,	July 70	Plate 29
	ETL 1110-2- 120,	May 71	Enclosure 3
Drop Structures			
Downstream	HDC 712-1	High Turbulence	
Upstream	HDC 712-1	Low Turbulence	

VELOCITIES AND RIPRAP SIZE

52. A velocity profile of the channel was produced using a Manning's "n" value of 0.031 which was reduced from the 0.035 value that was used to determine the water surface profile. This lower valve was determined using Strickler's equation:

$$n = k \; [\; D_{90} \; (\text{min}) \;]^{1/6}$$

53. Velocities for the high flow bench area were determined using the alpha method. Adjustments were made to account for the increased velocities in the outside channel bends using methods outlined in EM 1110-2-1601. Cross sections were added to determine velocities through the transitions and the riprap d_{30} valves are increased by 25-percent to account for turbulence. Froude numbers were determined for each bridge to identify the curve to be used on Plate 29 of reference c. Table A-16 shows the resulting channel velocity profile given by reach and structure.

TABLE A-16
Channel Velocities and Riprap Design Parameters

Station	Reach or Location	HEC-2 or Alpha Velocity	Adjusted outside Bend Vel.	Riprap Design Parameters D_{30}(ft)	W_{50}(lbs)
2+20	Confluence				
	to	8.5		0.28	
5+90	D/S 4th St. SE				
	to	9.2			200
6+65	U/S 4th St. SE				
	to	9.2	14.4	1.10	
10+00	End Channel Bend				
	to	9.2		0.33	
12+15	50 ft D/S Drop Structure				
	to	11.5			450
12+65	D/S Drop Structure				
13+00	U/S Drop Structure				
	to	16.2			450
13+25	25 ft U/S Drop Structure				
	to	8.5		0.28	
13+50	50 ft U/S Drop Structure				
	to	7.7		0.20	
16+50	Start Channel Bend				
	to	9.4	10.3	0.47	
19+00	End Channel Band				
	to	9.5		0.36	
23+00	D/S 6th St. SE				
	to	9.7			350
23+65	U/S 6th St. SE				
	to	10.0		0.40	
33+35	Transition & Start Bend				
	to	8.5/5.4	10.6/6.8	0.60/0.25	
41+00	End Channel Bend				
	to	8.5/5.4		0.28/0.01	
42+00	Start Channel Bend				
	to	8.5/5.4	10.6/6.8	0.48/0.20	
47+50	End Channel Bend				

TABLE A-16 (cont.)
Channel Velocities and Riprap Design Parameters

Station	Reach or Location	HEC-2 or Alpha Velocity	Adjusted outside Bend Vel.	Riprap Design Parameters D_{30}(ft)	Riprap Design Parameters W_{50}(lbs)
47+50	End Channel Bend				
	to	8.5/5.4		0.29/0.01	
60+35	Transition to Hwy 14				
	to	7.8		0.25	
61+70	D/S US Highway 14				
	to	8.1			100
62+80	U/S US Highway 14				
	to	7.7		0.25	
64+15	End of Bridge Transition				
	to	8.5/5.5	10.6/6.8		
68+85	Transition to Drop Structure				
	to	5.7		0.20	
71+10	25 ft D/S Drop Structure				
	to	6.5			14
71+35	D/S Drop Structure				
71+67	U/S Drop Structure				
	to	13.1			120
71+92	25 ft U/S Drop Structure				

RIPRAP GRADATIONS AND BEDDING THICKNESS

54. Table A-17 shows the riprap gradations and bedding thicknesses to be used throughout the project. Bedding gradations are shown in Appendix C. Gradations Type A through H are:

TABLE A-17
Riprap Gradations and Bedding Requirements

	Percent lighter by weight (lbs)							
	100		50		15			
Type	Max	Min	Max	Min	Max	Min	Bedding Thickness	Bedding Type
A	86	35	26	17	13	5	6"	4
B	292	117	86	58	43	18	9"	1
D	691	276	205	138	102	43	12"	2
F	984	394	292	197	146	62	12"	2
G	2331	933	691	467	346	146	12"-A & 6"	4
H	1098	439	463	220	232	69	12"-A & 6"	4

Notes: 1. Types A through G is taken from ETL 1110-2-120, enclosure 1.
2. Type H is taken from ETL 1110-2-120, enclosure 3.

RIPRAP - TYPE AND LOCATION

55. Using the design parameters for d_{30} and W_{50}, presented in Table A-16, the riprap design layout was made. Because of the possibility of vandalism, no exposed riprap is smaller than 18-inch Type B. Some portions of the side slopes through the project area are exposed bedrock; however, the exposed rock extends less than 6 feet above the proposed channel invert. Because of this, an erosion control system would be required at the top of rock elevation where the rock would meet the riprap or interlocking concrete slope protection. The erosion control system would consist of a bench or key to avoid undercutting of the slope protection. A bench would require additional excavation and a key would be highly susceptible to erosion or breakout. Therefore, these potential problems were eliminated by extending the riprap or interlocking concrete slope protection to the channel invert.

56. The low flow channel bottom through Slatterly Park and upstream of US Highway 14 will not be armored with riprap. Because of this, the side slope protection extends downward at a IV:2.5H slope to a depth 5 feet below the channel invert. Based on the WES sedimentation study (reference b), this depth is in excess of the anticipated scour. In areas where bedrock is encountered before the 5 foot depth, the riprap will extend down to the bedrock and then key into the bedrock a depth of 18-inches.

57. The low flow channel side slopes through Slatterly Park are protected with interlocking concrete slope protection down to the channel invert. From a point 2 feet above the invert to an elevation 5 feet below the invert, or to the existing rock elevation, Type B riprap is used. This protects the interlocking concrete slope protection from ice damage and provides toe protection for the slope.

58. The low flow channel side slopes upstream of US Highway 14 are protected by Type B riprap with 5 feet depth of toe protection.

59. High flow benches and side slopes, excluding transitions and outside bends, have velocities that can be suitably protected by turf (eg. bluegrass varieties). The high flow portion of transitions and outside bends will be protected by riprap or existing rock with topsoil and turf.

60. The termination of riprap protection upstream and downstream of the US Highway 14 transitions will require riprap end protection. Riprap end protection will also be used downstream of the upstream drop structure and at the termination of riprap protection upstream of the drop structure.

61. Bridge protection is extended upstream and downstream of the bridge due to the turbulent flow conditions near the bridge. The existing concrete abutments of 4th St. SE will be extended to the new channel invert. Concrete slope protection is proposed for 6th St. SE because of difficulties with placing large stone (W_{50} = 300 lbs). Vertical concrete walls are extended between the East bound and West bound bridges at US Highway 14.

62. Riprap layer thicknesses downstream of the drop structure stilling basins and through the bridges, are based on enclosure 3 of ETL 110-2-120 (reference d) because of high turbulence. Because water depths at the time of riprap placement are assumed to be low, riprap layer thicknesses for the remainder of the channel are based on placement in dry conditions.

63. The extent of scour protection, as well as riprap types and layer thicknesses, is presented in Table A-18.

TABLE A-18
Riprap Size and Location

Station and Location		Left Bank	Left Berm	Left Bank	Channel Bottom	Right Bank	Right Berm	Right Bank
	Confluence							
	to			exist	12"-A	ICSP		
3+35	260 ft D/S 4th St SE							
	to			*18"-B	12"-A	ICSP		
4+90	100 ft D/S 4th St SE							
	to			27"-F	27"-F	ICSP		
5+70	20 ft D/S 4th St SE							
	to			42"-H	42"-H	42"-H		
5+90	D/S face 4th St SE							
	to			conc.	42"-H	conc.		
6+65	U/S face 4th St SE							
	to			42"-H	42"-H	42"-H		
6+85	20 ft U/S 4th St SE							
	to			27"-F	27"-F	*24"-D		
10+40	Existing Rock at Invert							
	to			*18"-B	rock	*18"-B		
11+65	100 D/S Drop Structure							
	to			30"-D	rock	30"-D		
11+90	75 ft D/S Drop Structure							
	to			42"-H	rock	42"-H		
12+15	50 ft D/S Drop Structure							
	to			54"-G	rock	54"-G		
12+65	D/S End Drop Structure							
13+00	U/S End Drop Structure							
	to			36"-G	rock	36"-G		
13+25	25 ft U/S Drop Structure							
	to			24"-D	rock	24"-D		
13+50	50 ft U/S Drop Structure							
	to			*18"-B	rock	*18"-B		
22+90	10 ft D/S 6th St SE							
	to			conc.	rock	conc.		
23+75	10 ft U/S 6th St SE							
	to			*18"-B	rock	*18"-B		
33+35	Transition to High Flow							
	to	12"-A	rock	18"-B	rock	18"-B	rock	grass
34+00	Start Low Flow Rock Slope							
	to	12"-A	rock	rock	rock	rock	rock	grass
37+05	End of Transition							
	to	12"-A	rock	rock	rock	rock	rock	grass
38+00	End of Rock Berm							
	to	12"-A	12"-A	18"-B	rock	ICSP	grass	grass
41+00	Begin Right Bank Riprap							
	to	12"-A	12"-A	ICSP	rock	ICSP	12"-A	12"-A
42+00	End Left Bank Riprap							
	to	grass	grass	ICSP	rock	ICSP	12"-A	12"-A
47+00	End of Rock Bottom							
	to	grass	grass	ICSP	exist	ICSP	12"-A	12"-A
48+00	End Right Bank Riprap							
	to	grass	grass	ICSP	exist	ICSP	grass	grass
60+27	Riprap End Protection							
	to	grass	grass	ICSP	36"-B	ICSP	grass	grass
60+35	Transition to Hwy 14 (135 ft D/S Hwy 14)							
	to	12"-A	12"-A	18"-B	18"-B	18"-B	12"-A	12"-A
61+45	25 ft D/S face Hwy 14							

TABLE A-18 (cont.)
Riprap Size and Location

Station	and Location	Left Bank	Left Berm	Left Bank	Channel Bottom	Right Bank	Right Berm	Right Bank
61+45	25 ft D/S face Hwy 14							
	to			33"-D	33"-D	33"-D		
61+70	D/S face US Hwy 14							
	to			conc.	33"-D	conc.		
62+80	U/S face US Hwy 14							
	to			33"-D	33"-D	33"-D		
63+05	25 ft U/S Hwy 14							
	to	12"-A	12"-A	18"-B	18"-B	18"-B	12"-A	12"-A
64+15	Transition to Hwy 14 (135 ft U/S Hwy 14)							
	to	12"-A	12"-A	18"-B	36"-B	18"-B	grass	grass
64+23	End/Riprap End Protection							
	to	12"-A	12"-A	18"-B	exist	18"-B	grass	grass
68+80	End/Riprap End Protection							
	to	12"-A	12"-A	18"-B	24"-A	18"-B	12"-A	12"-A
68+85	Transition to Drop Structure (250 ft D/S Drop Structure)							
	to	12"-A	12"-A	18"-B	12"-A	18"-B	12"-A	12"-A
70+20	End of Bench							
	to			18"-B	18"-A	18"-B		
71+10	25 ft D/S Drop Structure							
	to			21"-B	21"-B	21"-B		
71+35	D/S End Drop Structure							
71+67	U/S End Drop Structure							
	to	24"-D	24"-D	24"-D	24"-D	24"-D	24"-D	24"-D
71+92	Riprap End Protection							
	to	48"-D	48"-D	48"-D	48"-D	48"-D	48"-D	48"-D
72+02	End of Protection							

Notes: 1. All 12" Type A used on side slopes is covered with top soil.
2. * 12" Type A with top soil on the 1V:3H portion of side slopes.
3. ICSP represents interlocking concrete slope protection.

CHANNEL MAINTENANCE

64. The widening and deepening of channels often encourages bed aggradation resulting in the need to periodically dredge the channel. This is done so that the channel will convey the design discharge such that the design water-surface elevations are not exceeded. Intermittent local deposition could occur and vegetation could prevent this deposition from being removed under scouring flow conditions. Therefore, local interests should prevent the establishment of extensive vegetation below the 20-year flow line.

65. The WES sedimentation study (reference b) indicated that no significant deposition would occur on Bear Creek for project conditions. However, this was based on a design channel being completely protected with riprap. Model simulations with only rock outcrops, bridges, drop structures, and weirs modified to prevent scour, revealed extensive sediment activity on Bear Creek. This activity was mostly scour. Therefore, some scour of the unprotected portion of the low flow channel is possible. The study indicated the maximum depth of scour was 5 feet. These scour holes are expected to fill during low flow events. Any sedimentation occurring downstream of the low flow channel is expected to fill in the voids of the riprap and form a meandering channel within the bottom width. This sedimentation is expected to scour away during a flood event and therefore, should not present a maintenance concern.

REFERENCES

The hydraulic design was performed using the following references:

a. Design Memorandum No. 1, Phase 2, General Project Design, Flood Control, South Fork Zumbro River, Rochester, Minnesota, September 1982.

b. Miscellaneous Paper HL-83-7, "Sedimentation Study for the Rochester, Minnesota, Flood Control Project", Waterways Experiment Station, October 1983.

c. EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", 1 July 1991 and 1 July 1970.

d. ETL 1110-2-120, "Engineering and Design, Additional Guidance for Riprap Channel Protection", 14 May 1971.

e. Technical Report HL-82-22, "South Fork Tillatoba Creek Drop Structures, Mississippi; Hydraulic Model Investigation", Waterways Experiment Station, September 1982.

f. Technical Report No. 2-760, "Drop Structure for Gering Valley Project, Scottsbluff County, Nebraska; Hydraulic Model Investigation", Waterways Experiment Station, February 1967.

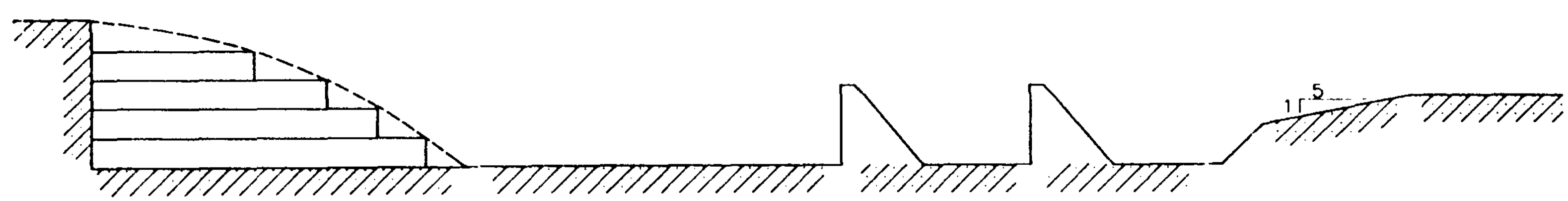
g. Technical Report No. 2-730, "Drop Structures for Walnut Creek Project, Walnut Creek, California; Hydraulic Model Investigation", Waterways Experiment Station, June 1966.

h. Technical Report No. 2-650, "Stability of Riprap and Discharge Characteristics, Overflow Embankments, Arkansas River, Arkansas; Hydraulic Model Investigation", Waterways Experiment Station, June 1964.

i. Hydraulic Design Criteria, Volumes 1 and 2, Waterways Experiment Station, June 1988.

j. EM 1110-2-1102, "Design Criteria for Systems of Small Dams", 19 February 1968.

k. Technical Report HL-92-1, "Brush Creek, Kansas City, Missouri; Hydraulic Model Investigation", Waterways Experiment Station, February 1992.



ALTERNATIVE
DROP STRUCTURE

```
*****************************************                                              THIS RUN EXECUTED 04/22/92    17:39:12
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.0;  February 1991
*****************************************


T1      ROCHESTER FLOOD CONTROL PROJECT - BEAR CREEK
T2      5 year event
T3      DM 6 DESIGN - FWC Jan 92

J1  ICHECK    INQ      NINV      IDIR      STRT     METRIC    HVINS     Q        WSEL      FQ

                2                                                               977.9

J2  NPROF     IPLOT    PRFVS     XSECV     XSECH     FN       ALLDC     IBW      CHNIM     ITRACE

      1                  -1


J5  LPRNT    NUMSEC                    *********REQUESTED SECTION NUMBERS*********

     -10      -10

NC     .1000     .10000    .03500    .10000    .30000
QT         7       3400      4300      5900      7200      8500      9700      22000
             ROCHESTER FLOOD CONTROL PROJECT - BEAR CREEK LOWER REACH
        *********************************************************************

        This model has the following features
            A. 80 ft BW from 4th St SE to the drop structure
            B. 60 ft BW from drop structure to Slatterly Park
            C. 65 ft BW through Statterly Park to U/S Drop Structure
                  1) With 7 ft bench ht and 22.5 ft bench width
            D. Side Slopes are 1V:2.5H up to the 20 year event and are
                 1V:3H the rest of the way up - D/S of Slatterly Park
                   1) 20-yr flow line is 8.5 ft above channel invert
            E. Model extends from Station 3+25 near mouth to U/S of US Hwy 14

        *********************************************************************
          STATION 3+25  85 ft U/S mouth          BW=80     SS=1:3
X1     1.000        18   10098.2   10251.2          0         0        0
GR     996.0    9020.0    994.00    9370.0     994.00    9780.0   985.30   10055.0    982.98   10098.2
GR     975.0   10122.0    971.70   10132.0     971.70   10212.0   975.03   10222.0    976.03   10225.0
GR     984.4   10250.0    984.76   10251.2     985.90   10275.0   987.10   10300.0    987.70   10325.0
GR     998.0   10380.0    990.00   10560.0    1000.00   10890.0

          STATION 5+68  25 ft D/S 4th St SE      BW=95     SS=1:3
X1     2.000        16   10276.0   10452.2      243.0     243.0    243.0
GR     995.2    9340.0    992.00    9530.0     990.00    9720.0   988.00    9830.0    988.00    9990.0
GR     988.9   10276.0    985.20   10287.0     980.53   10301.0   972.20   10326.0    972.20   10406.0
GR     977.2   10421.0    987.61   10452.2     990.00   10635.0   992.00   10805.0    996.00   10850.0
GR     998.0   11090.0
```

A-20

```
NC     .1000    .16000    .03000    .30000     .50000
             STATION 5+93  D/S face 4th St SE    BW=105    SS=1:1.5
                           (BW reduced 5 ft to account for bike path)
X1    2.400        13    10272.6   10463.3      25.0       25.0      25.0
CI       -1        -1        0.0         0         0       -105
X3      10.                                                                   988.60     988.60
GR    995.2    9340.0     992.00    9530.0    990.00     9720.0    990.77   10272.6     984.63   10291.0
GR    972.3   10328.0     972.30   10408.0    984.63    10445.0    990.72   10463.3     990.00   10635.0
GR    992.0   10805.0     996.00   10850.0    998.00    11090.0

SB     .900      1.56       3.00      0.00    105.00       3.00   1680.00     0.000       0.00      0.00
             STATION 6+73  U/S face 4th St SE    BW=110    SS=1:1.5
                           (has right bank bike path)
X1    2.500        17    10273.2   10462.7      80.0       80.0      80.0
CI                                                          .01
X2       0.      0.00         1.    986.70    990.70       0.00               0.000                0.000
X3      10.                                                                  990.70     990.70
BT      -11    9340.0     995.20      0.00    9530.0     992.00      0.00    9720.0     990.00      0.00
BT        0   10291.0     990.80      0.00   10292.0     994.30      0.00   10444.0     994.30      0.00
BT        0   10445.0     990.80      0.00   10635.0     990.00      0.00   10805.0     992.00      0.00
BT        0   10850.0     996.00      0.00   11090.0     998.00      0.00
GR    995.2    9340.0     992.00    9530.0    990.00     9720.0    990.78   10273.2     984.83   10308.0
GR    979.2   10308.0     972.30   10328.0    972.30    10408.0    977.60   10418.0     981.60   10418.0
GR    981.6   10428.0     984.83   10428.0    990.73    10462.7    990.00   10635.0     992.00   10805.0
GR    996.0   10850.0     998.00   11090.0

             STATION 7+23  50 ft U/S 4th St SE   BW=95     SS=1:2.5
                                                 BW=137.5  SS=1:3
X1    2.600        11    10273.2   10462.7        50         50        50
CI       -1     972.5        0.0       2.5       2.5        -95
CI       -1       981        0.0       3.0       3.0      137.5
X3      10.
GR    995.2    9340.0     992.00    9530.0    990.00     9720.0    990.78   10273.2     972.50   10328.0
GR    972.5   10408.0     990.73   10462.7    990.00    10635.0    992.00   10805.0     996.00   10850.0
GR    998.0   11090.0

NC     .1000    .17000    .03500    .10000     .30000
             STATION 10+00 Near bowling alley    BW=80     SS=1:2.5
             End of bridge transition            BW=122.5  SS=1:3
             (transition ends 200 ft U/S of bridge)
X1    3.000        20    10054.4   10220.1       530        150       277
CI       -1        -1        0.0       2.5       2.5        -80
CI       -1     981.6        0.0         3         3      122.5
GR   1000.0    9230.0     998.00    9290.0    992.00     9350.0    991.00    9800.0     986.75   10054.4
GR    975.9   10087.0     973.10   10095.0    973.10    10100.0    973.10   10170.0     973.10   10175.0
GR    976.5   10185.0     988.22   10220.1    988.32    10367.0    992.00   10450.0     994.00   10555.0
GR    998.2   10630.0     998.00   10820.0   1000.00    10970.0   1004.00   11010.0    1006.00   11060.0
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NC    .1100    .15000    .03500    .10000     .30000
           STATION 12+35 D/S of drop structure BW=80    SS=1:2.5
                                               BW=122.5 SS=1:3
X1   4.000         18   10395.7   10576.1       240       240       240
CI      -1         -1       0.0       2.5       2.5       -80
CI      -1        982       0.0         3         3     122.5
GR   999.0     9560.0    996.00    9632.5    995.22   10395.7    986.66   10417.1    980.49   10432.5
GR   980.1    10433.4    974.33   10447.9    973.50   10449.6    973.50   10529.6    974.33   10531.3
GR   979.8    10544.9    992.24   10576.1    992.30   10576.6    993.90   10728.7    994.00   10876.5
GR   998.0    10925.4   1000.00   11127.4   1006.00   11227.0

NC    .1000    .17000    .01700    .30000     .50000
           STATION 12+65 D/S lip of drop structure BW=75   SS=Vertical
X1   4.300          8      9750      9825        30        30        30
CI                                                        .01
CI                                                        .01
GR   999.0       9500     994.0      9550     992.0      9750     973.6      9750     973.6      9825
GR   992.0       9825     995.0     10225     999.0     10275

           STATION 13+03 U/S lip of drop structure BW=75   SS=Vertical
X1   4.600          8      9750      9825        38        38        38
GR   999.0       9500     992.0      9550     990.0      9750     977.8      9750     977.8      9825
GR   991.0       9825     993.0     10225     999.0     10275

NC    .1000    .17000    .03500    .30000     .50000
X1   4.800          0         0         0        25        25        25
CI      -1      977.9       0.0       2.5       2.5       -60
CI      -1      986.4       0.0         3         3     102.5
X5       8      983.9     984.9     986.1     986.6     987.9     989.1     990.1     996.2

           STATION 13+53 U/S of drop structure     BW=60    SS=1:2.5
                         End of Transition         BW=102.5 SS=1:3
X1     4.9          0         0         0        25        25        25
CI      -1        978       0.0       2.5       2.5       -60
CI      -1      986.5       0.0         3         3     102.5

NC    .1300    .10000    .03500    .10000     .30000
           STATION 15+20 Near convalescent home    BW=60    SS=1:2.5
                                                   BW=102.5 SS=1:3
X1   5.000         16    9992.7   10137.0       110       124       117
CI                                                        .01
CI      -1      986.9       0.0         3         3     102.5
GR  1002.1     9300.0   1002.10    9505.0   1000.00    9570.0    996.00    9630.0    993.91    9992.7
GR   984.2    10017.0    982.20   10022.0    978.40   10031.5    978.40   10091.5    979.80   10097.0
GR   980.2    10102.0    982.20   10117.0    990.29   10137.0    996.10   10250.0   1000.00   10285.0
GR  1003.0    10400.0

NC    .2000    .20000    .03500    .10000     .30000
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         STATION 19+10                            BW=60    SS=1:2.5
                                                  BW=102.5 SS=1:3
X1    6.000      16   10104.1   10239.5      380      420       400
CI       -1   988.1       0.0         3        3    102.5
GR   1002.0  9110.0   1002.00    9730.0   998.00   9910.0    995.16   10000.0    994.35   10104.1
GR    986.4 10124.0    981.20   10137.0   979.60  10142.0    979.60   10202.0    981.20   10207.0
GR    987.2 10222.0    994.20   10239.5   994.20  10325.0   1000.00   10470.0   1002.00   10820.0
GR   1004.6 10910.0

         STATION 22+25 80 ft D/S 6th St           BW=60    SS=1:2.5
                                                  BW=102.5 SS=1:3
X1    7.000      20   10054.6   10194.3      305      325       315
CI       -1   989.1       0.0         3        3    102.5
GR   1006.0  9610.0   1004.00    9650.0  1004.00   9800.0   1002.00    9880.0   1000.00    9900.0
GR    998.0  9930.0    996.84   10054.6   995.10  10059.0    987.50   10078.0    981.90   10092.0
GR    980.6 10097.0    980.60   10157.0   981.90  10162.0    987.90   10177.0    994.83   10194.3
GR    994.0 10415.0    996.00   10505.0   998.00  10640.0   1004.00   11170.0   1010.00   11230.0

NC    .2000  .20000    .03500    .30000   .50000
         STATION 23+05 6th St bridge - D/S face   BW=60    SS=1:2.5
                       (has right bank underpass)
X1    7.400      19   10066.7   10196.5       60      100        80
CI                                                    .01
X3      10.                                                            995.00    995.00
GR   1006.0  9770.0   1002.00    9900.0  1000.00   9930.0    998.00    9970.0    994.32   10066.7
GR    991.0 10075.0    985.40   10089.0   980.80  10102.0    980.80   10162.0    981.40   10165.0
GR    987.0 10179.0    994.00   10196.5   994.00  10220.0    996.00   10290.0    998.00   10815.0
GR   1000.0 10900.0   1002.00   11070.0  1004.00  11100.0   1007.00   11150.0

SB     .900    1.56      3.00      0.00    80.00     5.00   1180.00     1.000      0.00      0.00
         STATION 23+70 6th St bridge - U/S face   BW=60    SS=1.2.5
                       (has right bank underpass)
X1    7.500      19   10067.3   10196.0       70       70        70
X2       0.    0.00        1.    994.20   996.30     0.00               0.000               0.000
X3      10.                                                            996.40    996.40
BT      -11  9770.0   1006.00      0.00   9930.0  1000.00      0.00    9970.0    998.00      0.00
BT        0 10075.0    996.40      0.00  10076.0  1000.10      0.00   10178.0   1000.10      0.00
BT        0 10179.0    996.30      0.00  10815.0   998.00      0.00   10900.0   1000.00      0.00
BT        0 11070.0   1002.00      0.00  11150.0  1007.00      0.00
GR   1006.0  9770.0   1002.00    9900.0  1000.00   9930.0    998.00    9970.0    994.29   10067.3
GR    991.2 10075.0    985.60   10089.0   981.00  10102.0    981.00   10162.0    981.60   10165.0
GR    987.2 10179.0    994.00   10196.0   994.00  10220.0    996.00   10290.0    998.00   10815.0
GR   1000.0 10900.0   1002.00   11070.0  1004.00  11100.0   1007.00   11150.0

NC    .2000  .20000    .03500    .30000   .50000
         STATION 24+20                            BW=60    SS=1:2.5
                                                  BW=102.5 SS=1:3
X1    8.000      21   10028.4   10177.8       55       45        50
CI       -1   989.7       0.0         3        3    102.5
GR   1007.0  9830.0   1006.00    9970.0  1004.00   9990.0   1001.20   10000.0   1000.34   10028.4
GR    998.5 10033.0    990.50   10053.0   989.70  10055.0    982.90   10072.0    981.20   10077.0
GR    981.2 10137.0    982.90   10142.0   988.90  10157.0    996.10   10175.0    997.20   10177.8
GR    998.0 10640.0   1000.00   10840.0  1000.00  10980.0   1006.00   11150.0   1006.00   11500.0
GR   1008.0 11600.0
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NC     .2000    .20000    .03500    .10000     .30000
          STATION 28+20                        BW=60     SS=1.2.5
                                               BW=102.5  SS=1:3
X1    9.000        17   10099.0   10243.2        390       410       400
CI       -1     990.8       0.0         3          3     102.5
GR   1008.0    8970.0   1006.00    9140.0    1004.00    9430.0   1002.60    9580.0    999.72   10099.0
GR    991.3   10120.0    990.10   10123.0     984.10   10138.0    982.40   10143.0    982.40   10203.0
GR    984.1   10208.0    990.90   10225.0     998.17   10243.2   1000.00   10750.0   1002.00   11370.0
GR   1004.0   11390.0   1008.50   11540.0

          STATION 32+00                        BW=60     SS=1:2.5
                                               BW=102.5  SS=1:3
X1   10.000        14   10439.0   10602.0        380       380       380
CI       -1     991.9       0.0         3          3     102.5
GR   1004.0      9550    1002.0      9600     1002.0      9830    1004.0      9900    1004.0     10000
GR   1002.4   10430.0    997.00   10439.0     983.50   10480.0    983.50   10555.0    999.00   10602.0
GR   1000.5   10612.0   1002.00   11420.0    1006.00   11840.0   1010.00   12010.0

          Station 33+35   Start High/Low Flow  BW=60     SS=1:2.5
                                               BW=102.5  SS=1:3
X1     10.5         0         0         0        135       135       135                 0.4

          Section 11 was moved upstream
          STATION 35+65   Low Flow             BW=65     SS=1:3
                          High Flow (bw=berm width)bw=22.5  SS=1:3
X1   11.000        16   10472.0   10679.0        240       220       230                 0.5
CI       -1     984.4       0.0         3          3       -65
CI       -1     991.4       0.0         3          3       152
X4        1    1004.0      9980
GR   1004.0    9730.0   1002.80   10200.0    1001.20   10472.0    989.20   10510.0    989.20   10540.0
GR    984.4   10555.0    984.40   10605.0     989.20   10620.0    989.20   10650.0    999.00   10679.0
GR   1000.1   10700.0   1002.70   10709.0    1003.00   11720.0   1006.00   12220.0   1008.20   12250.0
GR   1010.0   12380.0

NC    .0500    .20000    .03500    .10000     .30000
          STATION 38+90   Low Flow             BW=65     SS=1:3
                          High Flow            bw=22.5   SS=1:3
X1   12.000        16   10217.0   10412.0        310       340       325
CI       -1     985.0       0.0         3          3       -65
CI       -1     992.0       0.0         3          3       152
X4        4      1004      8760      1004       8905      1004      9270      1004      9980
GR     1005      8730   1002.00   10125.0     999.50   10217.0    990.10   10245.0    990.10   10275.0
GR    985.0   10290.0    985.00   10340.0     990.10   10355.0    990.10   10385.0    999.00   10412.0
GR   1003.2   10439.0   1004.00   10810.0    1006.00   12000.0   1008.00   12125.0   1010.00   12185.0
GR   1012.0   12515.0

          STATION 40+40   Low Flow             BW=65     SS=1:3
                          High Flow            bw=22.5   SS=1:3
X1   13.000        18   10255.0   10439.0        150       150       150
CI       -1     985.3       0.0         3          3       -65
CI       -1     992.2       0.0         3          3       152
GR   1007.6    9800.0   1006.00    9900.0    1004.00    9950.0    998.40   10200.0    998.50   10255.0
GR    990.3   10280.0    990.30   10310.0     985.30   10325.0    985.30   10375.0    990.30   10390.0
```

GR	990.3	10420.0	996.60	10439.0	997.70	10450.0	999.60	10550.0	1003.50	10572.0
GR	1004.0	10780.0	1006.00	11970.0	1008.00	12095.0				
		STATION 43+05	Low Flow		BW=65	SS=1:3				
			High Flow		bw=22.5	SS=1:3				
X1	14.000	17	10218.0	10404.0	265	265	265			
CI	-1	985.8	0.0	3	3	-65				
CI	-1	992.8	0.0	3	3	152				
GR	1002.0	8560.0	1008.70	9430.0	1008.00	9525.0	1002.00	9800.0	1000.90	10000.0
GR	997.7	10218.0	990.70	10239.0	990.70	10269.0	985.80	10284.0	985.80	10334.0
GR	990.7	10349.0	990.70	10379.0	999.10	10404.0	1004.00	10635.0	1006.00	11940.0
GR	1010.0	11980.0	1011.00	12460.0						
		STATION 47+80	Low Flow		BW=65	SS=1:3				
			High Flow		bw=22.5	SS=1:3				
X1	15.000	21	10378.0	10562.0	455	495	475			
CI	-1	986.7	0.0	3	3	-65				
CI	-1	993.7	0.0	3	3	152				
GR	1010.0	9390.0	1006.00	9610.0	1004.00	9825.0	1002.00	9915.0	1000.00	9965.0
GR	999.5	10000.0	999.00	10378.0	991.60	10400.0	991.60	10430.0	986.70	10445.0
GR	986.7	10495.0	991.60	10510.0	991.60	10540.0	999.00	10562.0	999.20	10679.0
GR	1005.0	10693.0	1006.90	10725.0	1010.10	10840.0	1004.00	11280.0	1010.00	11950.0
GR	1011.8	12030.0								
		STATION 50+85	Low Flow		BW=65	SS=1:3				
			High flow		bw=22.5	SS=1:3				
X1	16.000	21	10261.0	10439.0	305	305	305			
CI	-1	987.3	0.0	3	3	-65				
CI	-1	994.3	0.0	3	3	152				
GR	1011.0	9280.0	1010.00	9400.0	1008.00	9640.0	1006.00	9665.0	1004.00	9735.0
GR	1002.0	9830.0	1000.00	9980.0	998.60	10261.0	992.20	10280.0	992.20	10310.0
GR	987.3	10325.0	987.30	10375.0	992.20	10390.0	992.20	10420.0	998.60	10439.0
GR	1000.1	10475.0	1003.90	10500.0	1006.00	10525.0	1006.00	10910.0	1010.00	11525.0
GR	1010.4	11650.0								
		STATION 51+90	Low Flow		BW=65	SS=1:3				
			High Flow		bw=22.5	SS=1:3				
X1	17.000	20	10274.0	10454.0	105	105	105			
CI	-1	987.4	0.0	3	3	-65				
CI	-1	994.4	0.0	3	3	152				
GR	1013.5	9320.0	1008.00	9680.0	1004.00	9690.0	1002.00	9915.0	1000.00	9955.0
GR	999.2	10274.0	992.40	10294.0	992.40	10324.0	987.40	10339.0	987.40	10389.0
GR	992.4	10404.0	992.40	10434.0	999.80	10454.0	1001.70	10600.0	1004.20	10621.0
GR	1004.3	10725.0	1006.00	10900.0	1008.00	11460.0	1010.00	11575.0	1010.40	11700.0
		STATION 55+30	Low Flow		BW=65	SS=1:3				
			High Flow		bw=22.5	SS=1:3				
X1	18.000	21	10062.0	10242.0	340	340	340			
CI	-1	988.1	0.0	3	3	-65				
CI	-1	995.1	0.0	3	3	152				
GR	1012.5	9010.0	1012.00	9155.0	1010.00	9260.0	1008.00	9360.0	1006.00	9390.0
GR	1004.0	9815.0	1000.60	10062.0	993.20	10084.0	993.20	10114.0	988.10	10129.0
GR	988.1	10179.0	993.20	10194.0	993.20	10224.0	999.20	10242.0	1001.10	10300.0
GR	1002.3	10450.0	1004.70	10475.0	1006.30	10700.0	1008.00	10930.0	1010.00	11105.0

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GR   1011.4    11480.0

ET                                                                        9800      10800        7.1
          STATION 60+35  Begin Bridge Transition  BW=65     SS=1:3
                                                  bw=22.5   SS=1:3
X1   19.000         21    10250.0    10439.0        510        500        505
CI       -1      989.0        0.0          3          3        -65
CI       -1      996.0        0.0          3          3        152
GR   1013.0     8370.0    1012.00     8520.0    1010.00     8880.0    1010.00     9000.0    1008.00     9170.0
GR   1006.0     9335.0    1006.00     9510.0    1004.20     9950.0    1003.80    10033.0    1001.50    10050.0
GR   1001.0    10250.0     990.50    10282.0     990.50    10289.0     989.00    10293.0     989.00    10389.0
GR    990.5    10393.0     990.50    10400.0    1003.60    10439.0    1006.00    10820.0    1010.00    11180.0
GR   1010.3    11750.0

NC    .0500     .05000     .03000     .30000     .50000
          STATION 61+70  D/S face US HWY 14 BRIDGE - MNDOT DESIGN SECTION USED
X1   19.100         11    10270.0    10380.0        135        135        135
CI                                                              .01
CI                                                              .01
X3      10.                                                                      1004.10    1004.10
GR   1012.0     8500.0    1006.00     9500.0    1004.30     9950.0    1004.00    10020.0    1004.10    10270.0
GR    989.2    10270.1     989.20    10379.9    1004.10    10380.0    1004.30    10480.0    1006.00    10890.0
GR   1010.0    11400.0

NC    .0500     .05000     .03000     .30000     .50000
ET                                                                        9400      10800        7.1
SB    1.250       1.56       3.00       0.00     110.00       4.00    1570.00      0.000     989.25      989.3
X1   19.200          0          0          0         35         35         35
X2       0.       0.00         1.    1004.10    1006.00       0.00                 0.000                 0.000
X3      10.                                                                       1006.0     1006.0
BT      -10     8500.0    1012.00       0.00     9500.0    1006.00       0.00     9950.0    1007.10       0.00
BT        0    10270.0    1007.10       0.00    10380.0    1007.10       0.00    10430.0    1007.10       0.00
BT        0    10680.0    1007.20       0.00    10780.0    1007.40       0.00    10850.0    1008.00       0.00
BT        0    11400.0    1010.00       0.00

ET                                                                        9400      10800        7.1
X1   19.300          8      10270      10380         40         40         40
X3      10.                                                                       1006.0     1006.0
GR   1012.0     8500.0    1006.00     9500.0    1005.40    10270.0     989.30    10270.1     989.30    10379.9
GR   1005.4    10380.0    1008.00    10890.0    1010.00    11400.0

ET                                                                        9400      10800        7.1
SB    1.250       1.56       3.00       0.00     110.00       4.00    1570.00      0.000     989.35     989.40
          STATION 62+80  U/S face US HWY 14 BRIDGE - NO MODIFICATION SCHEDULED
X1   19.400          0          0          0       40.0       40.0       40.0
X2       0.       0.00         1.    1005.40    1006.00       0.00                 0.000                 0.000
X3      10.                                                                      1006.00    1006.00
BT       -7     8500.0    1012.00       0.00     9500.0    1006.00       0.00    10270.0    1007.20       0.00
BT        0    10380.0    1007.30       0.00    10645.0    1007.40       0.00    10890.0      1008.       0.00
BT        0    11400.0    1010.00       0.00
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NC	.0500	.05000	.03500	.30000	.50000					
ET		9000	11400	2.1	2.1	2.1	2.1	2.1	2.1	
		STATION 64+15	End of Bridge Transition BW=65			SS=1:3				
					bw=22.5	SS:1:3				
X1	20.0	84	10750	10900	135	135	135			
CI	-1	989.6	0.0	3	3	-65				
CI	-1	996.6	0.0	3	3	152				
GR	1008.0	8440.0	1010.00	8610.0	1013.80	8820.0	1013.90	8930.0	1010.00	9160.0
GR	1008.0	9480.0	1007.00	9680.0	1006.00	9800.0	1006.00	9900.0	1004.00	9925.0
GR	1002.9	10000.0	1003.80	10025.0	1003.90	10029.0	1003.50	10050.0	1003.50	10075.0
GR	1003.8	10100.0	1003.70	10125.0	1003.10	10150.0	1003.00	10175.0	1002.70	10200.0
GR	1002.5	10225.0	1002.20	10250.0	1002.30	10275.0	1002.20	10300.0	1001.30	10318.0
GR	999.50	10329.0	1000.90	10339.0	1001.40	10350.0	1001.50	10375.0	1001.50	10400.0
GR	1001.2	10425.0	1000.70	10450.0	1001.00	10475.0	1001.00	10500.0	1000.80	10525.0
GR	1001.3	10675.0	1001.30	10700.0	1000.80	10725.0	1000.30	10750.0	999.50	10761.0
GR	996.40	10772.0	993.30	10775.0	993.10	10775.0	993.20	10785.0	992.50	10795.0
GR	992.40	10800.0	992.40	10805.0	992.60	10813.0	993.27	10813.0	995.10	10817.0
GR	995.60	10825.0	997.10	10850.0	994.80	10868.0	998.80	10883.0	1000.60	10900.0
GR	1001.6	11300.0	1001.60	11325.0	1002.30	11350.0	1003.60	11375.0	1004.51	11384.0
GR	1005.7	11400.0	1005.64	11413.0	1004.10	11425.0	1002.70	11434.0	1002.30	11450.0
GR	1002.6	11600.0	1002.50	11625.0	1002.90	11650.0	1003.00	11675.0	1003.10	11700.0
GR	1003.5	11725.0	1003.90	11750.0	1004.60	11775.0	1005.30	11800.0	1006.50	11825.0
GR	1007.0	11850.0	1007.70	11875.0	1008.30	11900.0	1008.90	11925.0	1009.20	11945.0
GR	1011.8	11956.0	1012.00	12055.0	1014.00	12170.0	1016.00	12475.0		

DM 6 DESIGN - FWC Jan 92

Starting profile number 1

T1 Rochester Flood Control Project - Bear Creek
T2 10 year event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		3							978.8	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2		-1							

DM 6 - Design

Starting profile number 2

T1 Rochester Flood Control Project - Bear Creek
T2 25 year event
T3 DM 6 - Design

	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
J1		4							980.2	

	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
J2	3		-1							

DM 6 - Design

Starting profile number 3

T1 Rochester Flood Control Project - Bear Creek
T2 50 year event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		5							981.0	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	4		-1							

DM 6 - Design

Starting profile number 4

T1 Rochester Flood Control Project - Bear Creek
T2 100 year event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		6							982.0	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	5		-1							

DM 6 - Design

Starting profile number 5

T1 Rochester Flood Control Project - Bear Creek
T2 Design Event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		7							983.0	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	6		-1							

DM 6 - Design

Starting profile number 6

T1 Rochester Flood Control Project - Bear Creek
T2 SPF Event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		8							994.5	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	7		-1							

DM 6 - Design

Starting profile number 7

THIS RUN EXECUTED 04/22/92 17:39:54

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.0; February 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

DM 6 DESIGN - FWC Jan 92

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	1.000	0.00	0.00	0.00	971.70	3400.00	977.90	0.00	978.38	19.37	5.56	611.73	772.58
	1.000	0.00	0.00	0.00	971.70	4300.00	978.80	0.00	979.35	19.17	5.98	719.65	982.00
	1.000	0.00	0.00	0.00	971.70	5900.00	980.20	0.00	980.87	18.96	6.58	897.15	1355.03
	1.000	0.00	0.00	0.00	971.70	7200.00	981.00	0.00	981.80	20.40	7.17	1003.83	1594.30
	1.000	0.00	0.00	0.00	971.70	8500.00	982.00	0.00	982.86	19.59	7.44	1142.55	1920.52
	1.000	0.00	0.00	0.00	971.70	9700.00	983.00	0.00	983.88	18.13	7.54	1287.25	2277.97
	1.000	0.00	0.00	0.00	971.70	22000.00	994.50	0.00	995.03	4.18	6.26	6331.23	10766.11
	2.000	243.00	0.00	0.00	972.20	3400.00	978.37	0.00	978.86	19.73	5.59	607.90	765.46
	2.000	243.00	0.00	0.00	972.20	4300.00	979.27	0.00	979.83	19.54	6.01	715.07	972.75
	2.000	243.00	0.00	0.00	972.20	5900.00	980.66	0.00	981.34	19.31	6.62	891.62	1342.58
	2.000	243.00	0.00	0.00	972.20	7200.00	981.50	0.00	982.30	20.46	7.18	1002.89	1591.61
	2.000	243.00	0.00	0.00	972.20	8500.00	982.47	0.00	983.34	19.79	7.46	1138.88	1910.88
	2.000	243.00	0.00	0.00	972.20	9700.00	983.44	0.00	984.33	18.52	7.59	1278.30	2253.72
	2.000	243.00	0.00	0.00	972.20	22000.00	994.81	0.00	995.14	3.27	5.21	9514.38	12174.21
	2.400	25.00	0.00	0.00	972.30	3400.00	978.49	0.00	978.91	11.41	5.23	649.55	1006.69
	2.400	25.00	0.00	0.00	972.30	4300.00	979.35	0.00	979.88	12.02	5.81	740.51	1240.27
	2.400	25.00	0.00	0.00	972.30	5900.00	980.69	0.00	981.39	13.02	6.69	881.92	1635.11
	2.400	25.00	0.00	0.00	972.30	7200.00	981.51	0.00	982.37	14.53	7.45	966.83	1889.13
	2.400	25.00	0.00	0.00	972.30	8500.00	982.46	0.00	983.44	14.90	7.97	1066.43	2201.99
	2.400	25.00	0.00	0.00	972.30	9700.00	983.39	0.00	984.46	14.78	8.33	1164.02	2523.12
*	2.400	25.00	0.00	0.00	972.30	22000.00	994.71	0.00	995.27	6.71	6.67	7419.14	8491.01
	2.500	80.00	990.70	986.70	972.30	3400.00	978.51	0.00	979.03	14.80	5.78	588.02	883.80
	2.500	80.00	990.70	986.70	972.30	4300.00	979.38	0.00	980.00	14.89	6.29	683.35	1114.18
	2.500	80.00	990.70	986.70	972.30	5900.00	980.73	0.00	981.51	15.01	7.09	831.93	1522.69
	2.500	80.00	990.70	986.70	972.30	7200.00	981.56	0.00	982.51	16.09	7.80	923.38	1794.80
	2.500	80.00	990.70	986.70	972.30	8500.00	982.52	0.00	983.56	17.25	8.19	1038.01	2046.66
	2.500	80.00	990.70	986.70	972.30	9700.00	983.46	0.00	984.56	16.26	8.43	1150.26	2405.79
	2.500	80.00	990.70	986.70	972.30	22000.00	994.76	0.00	995.27	4.46	6.23	7786.85	10416.90

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	2.600	50.00	0.00	0.00	972.50	3400.00	978.77	0.00	979.13	10.17	4.83	703.95	1066.32
	2.600	50.00	0.00	0.00	972.50	4300.00	979.69	0.00	980.11	10.09	5.21	825.48	1353.84
	2.600	50.00	0.00	0.00	972.50	5900.00	981.14	0.00	981.65	9.97	5.75	1025.96	1868.94
	2.600	50.00	0.00	0.00	972.50	7200.00	982.08	0.00	982.67	10.28	6.19	1162.46	2245.26
	2.600	50.00	0.00	0.00	972.50	8500.00	983.10	0.00	983.74	9.99	6.46	1315.54	2689.24
	2.600	50.00	0.00	0.00	972.50	9700.00	984.07	0.00	984.75	9.48	6.61	1467.51	3150.92
	2.600	50.00	0.00	0.00	972.50	22000.00	994.90	0.00	995.32	2.83	5.54	8414.67	13069.15
*	3.000	277.00	0.00	0.00	973.10	3400.00	979.04	0.00	979.60	23.44	6.03	563.38	702.31
*	3.000	277.00	0.00	0.00	973.10	4300.00	979.94	0.00	980.59	22.96	6.48	663.71	897.31
*	3.000	277.00	0.00	0.00	973.10	5900.00	981.35	0.00	982.13	22.34	7.11	829.76	1248.33
*	3.000	277.00	0.00	0.00	973.10	7200.00	982.27	0.00	983.18	22.91	7.62	944.50	1504.10
*	3.000	277.00	0.00	0.00	973.10	8500.00	983.26	0.00	984.24	22.23	7.92	1072.98	1802.83
*	3.000	277.00	0.00	0.00	973.10	9700.00	984.21	0.00	985.23	21.04	8.07	1201.33	2114.81
	3.000	277.00	0.00	0.00	973.10	22000.00	994.95	0.00	995.45	4.86	6.22	7662.46	9981.89
	4.000	240.00	0.00	0.00	973.50	3400.00	979.61	0.00	980.14	21.18	5.84	582.68	738.73
	4.000	240.00	0.00	0.00	973.50	4300.00	980.50	0.00	981.12	21.10	6.30	682.92	936.19
	4.000	240.00	0.00	0.00	973.50	5900.00	981.90	0.00	982.65	20.91	6.95	848.63	1290.22
	4.000	240.00	0.00	0.00	973.50	7200.00	982.86	0.00	983.71	21.61	7.43	969.54	1548.84
	4.000	240.00	0.00	0.00	973.50	8500.00	983.83	0.00	984.76	21.03	7.74	1098.12	1853.43
	4.000	240.00	0.00	0.00	973.50	9700.00	984.75	0.00	985.72	20.10	7.93	1223.36	2163.64
	4.000	240.00	0.00	0.00	973.50	22000.00	994.85	0.00	995.71	8.60	7.47	3330.96	7499.84
*	4.300	30.00	0.00	0.00	973.60	3400.00	979.45	0.00	980.38	9.03	7.74	439.04	1131.68
*	4.300	30.00	0.00	0.00	973.60	4300.00	980.28	0.00	981.42	9.52	8.58	501.17	1393.32
*	4.300	30.00	0.00	0.00	973.60	5900.00	981.56	0.00	983.08	10.37	9.87	597.51	1832.41
	4.300	30.00	0.00	0.00	973.60	7200.00	982.41	0.00	984.25	11.29	10.89	661.14	2142.48
	4.300	30.00	0.00	0.00	973.60	8500.00	983.28	0.00	985.41	11.78	11.70	726.53	2476.18
	4.300	30.00	0.00	0.00	973.60	9700.00	984.11	0.00	986.46	11.96	12.30	788.45	2805.21
	4.300	30.00	0.00	0.00	973.60	22000.00	993.67	987.43	996.94	8.64	14.55	1832.33	7482.46
*	4.600	38.00	0.00	0.00	977.80	3400.00	981.78	981.78	983.79	30.67	11.38	298.86	613.89
*	4.600	38.00	0.00	0.00	977.80	4300.00	982.46	982.46	984.81	29.84	12.31	349.19	787.23
*	4.600	38.00	0.00	0.00	977.80	5900.00	983.56	983.56	986.46	28.56	13.65	432.20	1104.02
*	4.600	38.00	0.00	0.00	977.80	7200.00	984.37	984.37	987.69	28.17	14.61	492.70	1356.63
*	4.600	38.00	0.00	0.00	977.80	8500.00	985.14	985.14	988.84	27.81	15.45	550.18	1611.89
*	4.600	38.00	0.00	0.00	977.80	9700.00	985.81	985.81	989.86	27.57	16.15	600.65	1847.33
*	4.600	38.00	0.00	0.00	977.80	22000.00	993.51	993.51	998.33	15.85	17.97	2292.85	5526.83
*	4.800	25.00	0.00	0.00	977.90	3400.00	983.90	0.00	984.78	38.37	7.54	450.94	548.92
*	4.800	25.00	0.00	0.00	977.90	4300.00	984.90	0.00	985.87	35.45	7.90	544.17	722.19
*	4.800	25.00	0.00	0.00	977.90	5900.00	986.10	0.00	987.33	37.73	8.90	662.92	960.46
*	4.800	25.00	0.00	0.00	977.90	7200.00	986.60	0.00	988.18	45.36	10.08	714.62	1069.08
*	4.800	25.00	0.00	0.00	977.90	8500.00	987.90	0.00	989.43	38.08	9.93	855.68	1377.40
*	4.800	25.00	0.00	0.00	977.90	9700.00	989.10	0.00	990.58	32.59	9.75	994.44	1699.23
*	4.800	25.00	0.00	0.00	977.90	22000.00	991.57	991.55	995.94	74.84	16.82	1406.86	2543.14

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
4.900	25.00	0.00	0.00	978.00	3400.00	983.99	0.00	984.88	38.68	7.56	449.69	546.71
4.900	25.00	0.00	0.00	978.00	4300.00	984.99	0.00	985.96	35.79	7.93	542.39	718.79
4.900	25.00	0.00	0.00	978.00	5900.00	986.19	0.00	987.43	38.02	8.92	661.14	956.82
4.900	25.00	0.00	0.00	978.00	7200.00	986.72	0.00	988.29	45.01	10.05	716.52	1073.16
4.900	25.00	0.00	0.00	978.00	8500.00	987.99	0.00	989.53	38.33	9.96	853.63	1372.89
4.900	25.00	0.00	0.00	978.00	9700.00	989.18	0.00	990.66	32.86	9.78	991.39	1692.13
* 4.900	25.00	0.00	0.00	978.00	22000.00	994.89	0.00	996.78	24.57	11.61	3465.74	4438.75
5.000	117.00	0.00	0.00	978.40	3400.00	984.66	0.00	985.28	26.46	6.32	537.88	660.98
5.000	117.00	0.00	0.00	978.40	4300.00	985.65	0.00	986.33	24.45	6.65	646.20	869.53
5.000	117.00	0.00	0.00	978.40	5900.00	986.98	0.00	987.82	24.51	7.38	799.87	1191.81
5.000	117.00	0.00	0.00	978.40	7200.00	987.73	0.00	988.74	26.54	8.07	891.74	1397.53
5.000	117.00	0.00	0.00	978.40	8500.00	988.89	0.00	989.93	23.92	8.20	1036.04	1738.02
5.000	117.00	0.00	0.00	978.40	9700.00	989.96	0.00	991.02	21.58	8.24	1176.47	2087.93
5.000	117.00	0.00	0.00	978.40	22000.00	995.11	0.00	997.10	24.24	11.40	2251.58	4468.20
6.000	400.00	0.00	0.00	979.60	3400.00	985.72	0.00	986.53	33.94	7.21	471.74	583.58
6.000	400.00	0.00	0.00	979.60	4300.00	986.62	0.00	987.54	33.45	7.73	556.43	743.52
6.000	400.00	0.00	0.00	979.60	5900.00	987.91	0.00	989.06	34.17	8.59	686.79	1009.25
6.000	400.00	0.00	0.00	979.60	7200.00	988.73	0.00	990.08	36.19	9.31	773.19	1196.89
6.000	400.00	0.00	0.00	979.60	8500.00	989.75	0.00	991.18	34.22	9.60	885.56	1452.97
6.000	400.00	0.00	0.00	979.60	9700.00	990.71	0.00	992.18	32.08	9.74	996.28	1712.68
6.000	400.00	0.00	0.00	979.60	22000.00	995.84	992.73	998.46	36.21	13.06	1960.31	3655.79
7.000	315.00	0.00	0.00	980.60	3400.00	986.80	0.00	987.56	31.14	6.97	487.93	609.30
7.000	315.00	0.00	0.00	980.60	4300.00	987.69	0.00	988.56	30.98	7.50	573.56	772.56
7.000	315.00	0.00	0.00	980.60	5900.00	989.03	0.00	990.10	31.31	8.31	710.41	1054.33
7.000	315.00	0.00	0.00	980.60	7200.00	989.94	0.00	991.17	32.41	8.89	809.89	1264.73
7.000	315.00	0.00	0.00	980.60	8500.00	990.90	0.00	992.23	31.56	9.25	919.25	1513.10
7.000	315.00	0.00	0.00	980.60	9700.00	991.78	0.00	993.17	30.32	9.47	1024.12	1761.71
7.000	315.00	0.00	0.00	980.60	22000.00	997.40	993.44	999.53	29.00	11.92	2738.61	4085.21
7.400	80.00	0.00	0.00	980.80	3400.00	987.06	0.00	987.81	30.87	6.95	488.86	611.90
7.400	80.00	0.00	0.00	980.80	4300.00	987.94	0.00	988.81	30.83	7.49	574.01	774.49
7.400	80.00	0.00	0.00	980.80	5900.00	989.28	0.00	990.35	31.17	8.30	711.00	1056.78
7.400	80.00	0.00	0.00	980.80	7200.00	990.20	0.00	991.42	31.90	8.89	809.99	1274.76
7.400	80.00	0.00	0.00	980.80	8500.00	991.15	0.00	992.48	31.24	9.28	916.43	1520.80
7.400	80.00	0.00	0.00	980.80	9700.00	992.01	0.00	993.42	30.19	9.53	1017.81	1765.39
7.400	80.00	0.00	0.00	980.80	22000.00	997.49	993.77	999.91	29.63	12.60	2395.13	4041.53
7.500	70.00	996.30	994.20	981.00	3400.00	987.17	0.00	987.95	32.52	7.08	480.34	596.24
7.500	70.00	996.30	994.20	981.00	4300.00	988.08	0.00	988.97	31.96	7.58	566.97	760.64
7.500	70.00	996.30	994.20	981.00	5900.00	989.45	0.00	990.53	31.70	8.35	706.84	1047.87
7.500	70.00	996.30	994.20	981.00	7200.00	990.40	0.00	991.63	32.04	8.90	808.79	1272.06
7.500	70.00	996.30	994.20	981.00	8500.00	991.36	0.00	992.69	31.20	9.27	916.86	1521.84
7.500	70.00	996.30	994.20	981.00	9700.00	992.23	0.00	993.64	30.10	9.52	1018.84	1768.01
7.500	70.00	996.30	994.20	981.00	22000.00	997.33	0.00	999.91	32.45	13.00	2260.50	3861.88

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
8.000	50.00	0.00	0.00	981.20	3400.00	987.32	0.00	988.14	34.19	7.24	469.86	581.46
8.000	50.00	0.00	0.00	981.20	4300.00	988.22	0.00	989.15	33.71	7.76	554.19	740.66
8.000	50.00	0.00	0.00	981.20	5900.00	989.59	0.00	990.72	33.57	8.55	690.24	1018.36
8.000	50.00	0.00	0.00	981.20	7200.00	990.54	0.00	991.81	34.66	9.06	795.09	1223.04
8.000	50.00	0.00	0.00	981.20	8500.00	991.50	0.00	992.87	33.44	9.39	904.84	1469.83
8.000	50.00	0.00	0.00	981.20	9700.00	992.37	0.00	993.81	32.00	9.61	1009.07	1714.79
8.000	50.00	0.00	0.00	981.20	22000.00	997.51	994.29	1000.09	37.77	12.90	1732.22	3579.64
9.000	400.00	0.00	0.00	982.40	3400.00	988.68	0.00	989.45	31.37	7.03	483.83	607.08
9.000	400.00	0.00	0.00	982.40	4300.00	989.57	0.00	990.46	31.37	7.57	568.01	767.73
9.000	400.00	0.00	0.00	982.40	5900.00	990.95	0.00	992.03	31.78	8.33	707.86	1046.57
9.000	400.00	0.00	0.00	982.40	7200.00	991.93	0.00	993.15	31.79	8.84	814.15	1276.91
9.000	400.00	0.00	0.00	982.40	8500.00	992.84	0.00	994.18	31.60	9.26	917.54	1511.97
9.000	400.00	0.00	0.00	982.40	9700.00	993.65	0.00	995.07	31.21	9.58	1012.42	1736.40
9.000	400.00	0.00	0.00	982.40	22000.00	999.12	995.57	1001.54	34.24	12.51	1878.57	3759.95
10.000	380.00	0.00	0.00	983.50	3400.00	989.91	0.00	990.40	19.22	5.61	606.39	775.44
10.000	380.00	0.00	0.00	983.50	4300.00	990.84	0.00	991.40	19.04	6.02	714.25	985.56
10.000	380.00	0.00	0.00	983.50	5900.00	992.31	0.00	992.98	18.59	6.59	895.79	1368.37
10.000	380.00	0.00	0.00	983.50	7200.00	993.34	0.00	994.10	18.44	6.98	1032.02	1676.65
10.000	380.00	0.00	0.00	983.50	8500.00	994.29	0.00	995.12	18.28	7.31	1163.04	1988.16
10.000	380.00	0.00	0.00	983.50	9700.00	995.12	0.00	996.01	18.08	7.57	1281.51	2281.43
10.000	380.00	0.00	0.00	983.50	22000.00	1001.01	0.00	1002.54	17.55	9.93	2308.25	5251.99
10.500	135.00	0.00	0.00	983.90	3400.00	990.16	0.00	990.68	21.02	5.78	588.31	741.64
10.500	135.00	0.00	0.00	983.90	4300.00	991.09	0.00	991.68	20.54	6.18	695.89	948.81
10.500	135.00	0.00	0.00	983.90	5900.00	992.54	0.00	993.25	19.90	6.74	874.91	1322.64
10.500	135.00	0.00	0.00	983.90	7200.00	993.57	0.00	994.36	19.64	7.13	1009.62	1624.80
10.500	135.00	0.00	0.00	983.90	8500.00	994.52	0.00	995.39	19.39	7.46	1139.11	1930.21
10.500	135.00	0.00	0.00	983.90	9700.00	995.35	0.00	996.27	19.13	7.72	1256.09	2217.62
10.500	135.00	0.00	0.00	983.90	22000.00	1001.22	0.00	1002.79	18.41	10.08	2231.55	5127.65
11.000	230.00	0.00	0.00	984.40	3400.00	990.61	0.00	991.27	27.85	6.54	519.99	644.26
11.000	230.00	0.00	0.00	984.40	4300.00	991.64	0.00	992.34	38.32	6.73	638.67	694.60
11.000	230.00	0.00	0.00	984.40	5900.00	993.07	0.00	993.80	28.33	6.82	864.71	1108.39
11.000	230.00	0.00	0.00	984.40	7200.00	994.12	0.00	994.87	24.21	6.94	1037.84	1463.45
11.000	230.00	0.00	0.00	984.40	8500.00	995.09	0.00	995.87	21.54	7.06	1204.20	1831.48
11.000	230.00	0.00	0.00	984.40	9700.00	995.93	0.00	996.73	19.78	7.17	1353.05	2180.75
11.000	230.00	0.00	0.00	984.40	22000.00	1002.08	0.00	1003.22	14.98	8.56	2624.11	5684.37
12.000	325.00	0.00	0.00	985.00	3400.00	991.52	0.00	992.11	23.46	6.17	551.47	701.95
12.000	325.00	0.00	0.00	985.00	4300.00	992.82	0.00	993.36	25.41	5.90	729.30	853.11
12.000	325.00	0.00	0.00	985.00	5900.00	994.00	0.00	994.64	23.58	6.43	918.27	1214.98
12.000	325.00	0.00	0.00	985.00	7200.00	994.92	0.00	995.62	21.97	6.72	1071.59	1536.11
12.000	325.00	0.00	0.00	985.00	8500.00	995.80	0.00	996.55	20.54	6.95	1223.33	1875.34
12.000	325.00	0.00	0.00	985.00	9700.00	996.58	0.00	997.37	19.48	7.13	1360.01	2197.51
12.000	325.00	0.00	0.00	985.00	22000.00	1002.55	0.00	1003.70	14.34	8.66	2721.00	5810.14

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
13.000	150.00	0.00	0.00	985.30	3400.00	991.88	0.00	992.46	22.69	6.10	557.80	713.72
13.000	150.00	0.00	0.00	985.30	4300.00	993.22	0.00	993.73	23.40	5.74	749.75	888.84
13.000	150.00	0.00	0.00	985.30	5900.00	994.37	0.00	994.99	22.21	6.29	937.36	1251.83
13.000	150.00	0.00	0.00	985.30	7200.00	995.26	0.00	995.95	21.17	6.63	1085.77	1564.75
13.000	150.00	0.00	0.00	985.30	8500.00	996.12	0.00	996.86	20.12	6.89	1232.89	1894.92
13.000	150.00	0.00	0.00	985.30	9700.00	996.88	0.00	997.66	19.44	7.09	1368.75	2199.79
13.000	150.00	0.00	0.00	985.30	22000.00	1002.99	0.00	1003.91	11.58	8.04	3743.76	6465.35
14.000	265.00	0.00	0.00	985.80	3400.00	992.49	0.00	993.04	21.37	5.97	569.47	735.55
14.000	265.00	0.00	0.00	985.80	4300.00	993.84	0.00	994.34	22.02	5.63	763.89	916.31
14.000	265.00	0.00	0.00	985.80	5900.00	994.97	0.00	995.57	21.51	6.23	946.42	1272.19
14.000	265.00	0.00	0.00	985.80	7200.00	995.83	0.00	996.50	20.80	6.60	1091.13	1578.64
14.000	265.00	0.00	0.00	985.80	8500.00	996.65	0.00	997.39	20.05	6.89	1233.18	1898.08
14.000	265.00	0.00	0.00	985.80	9700.00	997.39	0.00	998.18	19.29	7.11	1364.67	2208.76
14.000	265.00	0.00	0.00	985.80	22000.00	1003.45	0.00	1004.22	10.33	7.54	4427.10	6846.02
15.000	475.00	0.00	0.00	986.70	3400.00	993.50	0.00	994.03	20.18	5.85	580.78	756.87
15.000	475.00	0.00	0.00	986.70	4300.00	994.88	0.00	995.34	20.27	5.48	784.75	955.10
15.000	475.00	0.00	0.00	986.70	5900.00	995.98	0.00	996.56	20.30	6.12	964.53	1309.42
15.000	475.00	0.00	0.00	986.70	7200.00	996.82	0.00	997.47	19.95	6.51	1106.25	1611.79
15.000	475.00	0.00	0.00	986.70	8500.00	997.61	0.00	998.33	19.65	6.85	1241.62	1917.58
15.000	475.00	0.00	0.00	986.70	9700.00	998.31	0.00	999.09	19.18	7.09	1367.22	2214.93
15.000	475.00	0.00	0.00	986.70	22000.00	1004.13	0.00	1004.67	8.22	6.72	5314.84	7673.49
16.000	305.00	0.00	0.00	987.30	3400.00	994.12	0.00	994.64	19.91	5.83	583.47	761.95
16.000	305.00	0.00	0.00	987.30	4300.00	995.49	0.00	995.96	20.04	5.46	787.69	960.60
16.000	305.00	0.00	0.00	987.30	5900.00	996.60	0.00	997.18	19.99	6.09	969.41	1319.51
16.000	305.00	0.00	0.00	987.30	7200.00	997.42	0.00	998.08	19.89	6.50	1107.39	1614.29
16.000	305.00	0.00	0.00	987.30	8500.00	998.21	0.00	998.93	19.61	6.84	1242.51	1919.67
16.000	305.00	0.00	0.00	987.30	9700.00	998.89	0.00	999.68	19.06	7.11	1374.02	2221.59
16.000	305.00	0.00	0.00	987.30	22000.00	1004.33	0.00	1004.98	9.64	7.23	4612.94	7084.59
17.000	105.00	0.00	0.00	987.40	3400.00	994.34	0.00	994.85	18.81	5.71	595.04	783.99
17.000	105.00	0.00	0.00	987.40	4300.00	995.72	0.00	996.16	18.63	5.33	806.59	996.25
17.000	105.00	0.00	0.00	987.40	5900.00	996.83	0.00	997.38	18.89	5.97	987.74	1357.63
17.000	105.00	0.00	0.00	987.40	7200.00	997.65	0.00	998.29	18.79	6.38	1128.48	1660.92
17.000	105.00	0.00	0.00	987.40	8500.00	998.43	0.00	999.14	18.63	6.72	1263.96	1969.56
17.000	105.00	0.00	0.00	987.40	9700.00	999.11	0.00	999.88	18.44	7.00	1385.31	2258.77
17.000	105.00	0.00	0.00	987.40	22000.00	1004.44	0.00	1005.08	9.76	7.19	4933.48	7042.88
18.000	340.00	0.00	0.00	988.10	3400.00	994.98	0.00	995.50	19.23	5.76	590.53	775.37
18.000	340.00	0.00	0.00	988.10	4300.00	996.36	0.00	996.81	19.27	5.39	797.82	979.66
18.000	340.00	0.00	0.00	988.10	5900.00	997.47	0.00	998.04	19.27	6.01	981.16	1343.91
18.000	340.00	0.00	0.00	988.10	7200.00	998.29	0.00	998.94	19.24	6.43	1119.67	1641.39
18.000	340.00	0.00	0.00	988.10	8500.00	999.07	0.00	999.78	19.09	6.78	1253.64	1945.50
18.000	340.00	0.00	0.00	988.10	9700.00	999.74	0.00	1000.51	18.91	7.06	1378.06	2230.62
18.000	340.00	0.00	0.00	988.10	22000.00	1004.47	0.00	1005.68	16.96	9.16	3472.62	5342.81

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	19.000	505.00	0.00	0.00	989.00	3400.00	995.95	0.00	996.46	18.71	5.70	596.06	785.93
	19.000	505.00	0.00	0.00	989.00	4300.00	997.32	0.00	997.76	18.55	5.32	807.73	998.42
	19.000	505.00	0.00	0.00	989.00	5900.00	998.44	0.00	999.00	18.74	5.96	990.29	1362.96
	19.000	505.00	0.00	0.00	989.00	7200.00	999.27	0.00	999.90	18.75	6.38	1129.38	1662.92
	19.000	505.00	0.00	0.00	989.00	8500.00	1000.03	0.00	1000.74	18.69	6.73	1262.43	1965.97
	19.000	505.00	0.00	0.00	989.00	9700.00	1000.70	0.00	1001.46	18.62	7.02	1380.89	2248.03
	19.000	505.00	0.00	0.00	989.00	22000.00	1005.59	0.00	1006.48	13.82	8.14	3910.88	5918.63
*	19.100	135.00	0.00	0.00	989.20	3400.00	996.37	0.00	996.66	6.46	4.32	787.83	1337.69
*	19.100	135.00	0.00	0.00	989.20	4300.00	997.59	0.00	997.93	6.30	4.67	921.17	1713.69
*	19.100	135.00	0.00	0.00	989.20	5900.00	998.67	0.00	999.17	8.08	5.67	1040.57	2076.01
*	19.100	135.00	0.00	0.00	989.20	7200.00	999.44	0.00	1000.07	9.44	6.40	1124.21	2343.07
	19.100	135.00	0.00	0.00	989.20	8500.00	1000.18	0.00	1000.95	10.55	7.04	1206.86	2617.08
	19.100	135.00	0.00	0.00	989.20	9700.00	1000.83	0.00	1001.72	11.51	7.59	1277.61	2859.16
	19.100	135.00	0.00	0.00	989.20	22000.00	1005.16	999.92	1007.36	20.42	12.10	2388.60	4868.15
	19.200	35.00	1006.00	1004.10	989.20	3400.00	996.40	0.00	996.69	6.38	4.30	790.86	1345.88
	19.200	35.00	1006.00	1004.10	989.20	4300.00	997.62	0.00	997.96	6.20	4.65	925.48	1726.37
	19.200	35.00	1006.00	1004.10	989.20	5900.00	998.73	0.00	999.22	7.94	5.64	1046.47	2094.49
	19.200	35.00	1006.00	1004.10	989.20	7200.00	999.51	0.00	1000.14	9.22	6.36	1132.87	2371.32
	19.200	35.00	1006.00	1004.10	989.20	8500.00	1000.28	0.00	1001.04	10.27	6.98	1217.33	2652.46
	19.200	35.00	1006.00	1004.10	989.20	9700.00	1000.94	0.00	1001.82	11.16	7.52	1290.35	2903.47
*	19.200	35.00	1006.00	1004.10	989.20	22000.00	1006.96	0.00	1007.96	9.74	8.97	4851.22	7049.86
	19.300	40.00	0.00	0.00	989.30	3400.00	996.42	0.00	996.72	6.60	4.34	782.67	1323.80
	19.300	40.00	0.00	0.00	989.30	4300.00	997.65	0.00	997.99	6.38	4.69	917.21	1702.07
	19.300	40.00	0.00	0.00	989.30	5900.00	998.75	0.00	999.25	8.12	5.68	1038.96	2070.95
	19.300	40.00	0.00	0.00	989.30	7200.00	999.54	0.00	1000.18	9.40	6.39	1125.92	2348.65
	19.300	40.00	0.00	0.00	989.30	8500.00	1000.32	0.00	1001.08	10.44	7.02	1210.85	2630.54
	19.300	40.00	0.00	0.00	989.30	9700.00	1000.98	0.00	1001.87	11.33	7.55	1284.28	2882.31
	19.300	40.00	0.00	0.00	989.30	22000.00	1006.58	1000.02	1008.43	15.87	11.12	2748.04	5523.31
	19.400	40.00	1006.00	1005.40	989.30	3400.00	996.45	0.00	996.74	6.52	4.33	785.49	1331.39
	19.400	40.00	1006.00	1005.40	989.30	4300.00	997.68	0.00	998.02	6.31	4.67	920.51	1711.76
	19.400	40.00	1006.00	1005.40	989.30	5900.00	998.81	0.00	999.30	7.98	5.65	1044.51	2088.34
	19.400	40.00	1006.00	1005.40	989.30	7200.00	999.62	0.00	1000.24	9.20	6.35	1133.59	2373.66
	19.400	40.00	1006.00	1005.40	989.30	8500.00	1000.41	0.00	1001.16	10.18	6.96	1220.72	2663.93
	19.400	40.00	1006.00	1005.40	989.30	9700.00	1001.10	0.00	1001.97	11.00	7.48	1296.32	2924.29
	19.400	40.00	1006.00	1005.40	989.30	22000.00	1006.58	0.00	1008.43	15.88	11.12	2745.75	5521.53
*	20.000	135.00	0.00	0.00	989.60	3400.00	996.48	0.00	997.00	19.37	5.77	589.08	772.62
*	20.000	135.00	0.00	0.00	989.60	4300.00	997.76	0.00	998.22	20.39	5.49	783.19	952.17
*	20.000	135.00	0.00	0.00	989.60	5900.00	998.93	0.00	999.50	19.87	6.07	971.31	1323.44
*	20.000	135.00	0.00	0.00	989.60	7200.00	999.78	0.00	1000.43	19.42	6.45	1116.67	1633.65
	20.000	135.00	0.00	0.00	989.60	8500.00	1000.67	0.00	1001.36	18.26	6.69	1279.64	1989.04
	20.000	135.00	0.00	0.00	989.60	9700.00	1001.54	0.00	1002.20	15.35	6.62	1791.74	2475.60
*	20.000	135.00	0.00	0.00	989.60	22000.00	1008.93	0.00	1009.01	1.51	3.20	12993.54	17879.19

DM 6 DESIGN - FWC Jan 92

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	1.000	3400.00	977.90	0.00	0.00	0.00	117.23	0.00
	1.000	4300.00	978.80	.90	0.00	0.00	122.61	0.00
	1.000	5900.00	980.20	1.40	0.00	0.00	130.96	0.00
	1.000	7200.00	981.00	.80	0.00	0.00	135.74	0.00
	1.000	8500.00	982.00	1.00	0.00	0.00	141.71	0.00
	1.000	9700.00	983.00	1.00	0.00	0.00	147.99	0.00
	1.000	22000.00	994.50	11.50	0.00	0.00	1328.56	0.00
	2.000	3400.00	978.37	0.00	.47	0.00	117.03	243.00
	2.000	4300.00	979.27	.89	.47	0.00	122.40	243.00
	2.000	5900.00	980.66	1.39	.46	0.00	130.76	243.00
	2.000	7200.00	981.50	.84	.50	0.00	135.77	243.00
	2.000	8500.00	982.47	.98	.47	0.00	141.65	243.00
	2.000	9700.00	983.44	.96	.44	0.00	147.43	243.00
	2.000	22000.00	994.81	11.38	.31	0.00	1473.81	243.00
	2.400	3400.00	978.49	0.00	.12	0.00	105.00	25.00
	2.400	4300.00	979.35	.87	.09	0.00	105.00	25.00
	2.400	5900.00	980.69	1.34	.03	0.00	105.00	25.00
	2.400	7200.00	981.51	.82	.01	0.00	105.00	25.00
	2.400	8500.00	982.46	.95	-.02	0.00	105.00	25.00
	2.400	9700.00	983.39	.93	-.05	0.00	105.00	25.00
*	2.400	22000.00	994.71	11.32	-.11	0.00	1466.04	25.00
	2.500	3400.00	978.51	0.00	.02	0.00	107.99	80.00
	2.500	4300.00	979.38	.87	.03	0.00	110.00	80.00
	2.500	5900.00	980.73	1.35	.04	0.00	110.00	80.00
	2.500	7200.00	981.56	.83	.05	0.00	110.00	80.00
	2.500	8500.00	982.52	.96	.06	0.00	120.00	80.00
	2.500	9700.00	983.46	.94	.07	0.00	120.00	80.00
	2.500	22000.00	994.76	11.30	.05	0.00	1469.86	80.00
	2.600	3400.00	978.77	0.00	.26	0.00	129.43	50.00
	2.600	4300.00	979.69	.92	.31	0.00	134.49	50.00
	2.600	5900.00	981.14	1.45	.41	0.00	142.43	50.00
	2.600	7200.00	982.08	.94	.52	0.00	147.60	50.00
	2.600	8500.00	983.10	1.02	.58	0.00	153.19	50.00
	2.600	9700.00	984.07	.97	.61	0.00	158.54	50.00
	2.600	22000.00	994.90	10.83	.14	0.00	1479.93	50.00
*	3.000	3400.00	979.04	0.00	.27	0.00	109.70	277.00
*	3.000	4300.00	979.94	.90	.24	0.00	114.18	277.00
*	3.000	5900.00	981.35	1.41	.21	0.00	121.24	277.00
*	3.000	7200.00	982.27	.93	.19	0.00	126.54	277.00
*	3.000	8500.00	983.26	.99	.17	0.00	132.49	277.00
*	3.000	9700.00	984.21	.95	.14	0.00	138.18	277.00
	3.000	22000.00	994.95	10.74	.05	0.00	1251.58	277.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	4.000	3400.00	979.61	0.00	.57	0.00	110.58	240.00
	4.000	4300.00	980.50	.89	.57	0.00	115.02	240.00
	4.000	5900.00	981.90	1.40	.56	0.00	122.01	240.00
	4.000	7200.00	982.86	.95	.58	0.00	129.28	240.00
	4.000	8500.00	983.83	.97	.57	0.00	134.63	240.00
	4.000	9700.00	984.75	.91	.53	0.00	139.66	240.00
	4.000	22000.00	994.85	10.11	-.10	0.00	502.88	240.00
*	4.300	3400.00	979.45	0.00	-.16	0.00	75.00	30.00
*	4.300	4300.00	980.28	.83	-.22	0.00	75.00	30.00
*	4.300	5900.00	981.56	1.28	-.34	0.00	75.00	30.00
	4.300	7200.00	982.41	.85	-.45	0.00	75.00	30.00
	4.300	8500.00	983.28	.87	-.55	0.00	75.00	30.00
	4.300	9700.00	984.11	.82	-.64	0.00	75.00	30.00
	4.300	22000.00	993.67	9.57	-1.18	0.00	465.52	30.00
*	4.600	3400.00	981.78	0.00	2.33	0.00	75.00	38.00
*	4.600	4300.00	982.46	.67	2.18	0.00	75.00	38.00
*	4.600	5900.00	983.56	1.11	2.00	0.00	75.00	38.00
*	4.600	7200.00	984.37	.81	1.96	0.00	75.00	38.00
*	4.600	8500.00	985.14	.77	1.86	0.00	75.00	38.00
*	4.600	9700.00	985.81	.67	1.70	0.00	75.00	38.00
*	4.600	22000.00	993.51	7.70	-.16	0.00	690.02	38.00
*	4.800	3400.00	983.90	0.00	2.12	0.00	90.63	25.00
*	4.800	4300.00	984.90	1.00	2.44	0.00	95.84	25.00
*	4.800	5900.00	986.10	1.20	2.54	0.00	102.09	25.00
*	4.800	7200.00	986.60	.50	2.23	0.00	104.79	25.00
*	4.800	8500.00	987.90	1.30	2.76	0.00	112.21	25.00
*	4.800	9700.00	989.10	1.20	3.29	0.00	119.06	25.00
*	4.800	22000.00	991.57	2.47	-1.94	0.00	344.60	25.00
	4.900	3400.00	983.99	0.00	.09	0.00	90.55	25.00
	4.900	4300.00	984.99	.99	.09	0.00	95.73	25.00
	4.900	5900.00	986.19	1.21	.09	0.00	101.98	25.00
	4.900	7200.00	986.72	.53	.12	0.00	104.88	25.00
	4.900	8500.00	987.99	1.27	.09	0.00	112.09	25.00
	4.900	9700.00	989.18	1.19	.08	0.00	118.90	25.00
*	4.900	22000.00	994.89	5.71	3.33	0.00	711.35	25.00
	5.000	3400.00	984.66	0.00	.66	0.00	107.23	117.00
	5.000	4300.00	985.65	.99	.66	0.00	112.15	117.00
	5.000	5900.00	986.98	1.33	.78	0.00	118.77	117.00
	5.000	7200.00	987.73	.76	1.01	0.00	122.56	117.00
	5.000	8500.00	988.89	1.15	.89	0.00	128.28	117.00
	5.000	9700.00	989.96	1.07	.78	0.00	133.61	117.00
	5.000	22000.00	995.11	5.15	.22	0.00	446.79	117.00

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
6.000	3400.00	985.72	0.00	1.06	0.00	92.61	400.00
6.000	4300.00	986.62	.89	.97	0.00	97.08	400.00
6.000	5900.00	987.91	1.30	.94	0.00	103.58	400.00
6.000	7200.00	988.73	.82	1.00	0.00	107.67	400.00
6.000	8500.00	989.75	1.02	.87	0.00	112.79	400.00
6.000	9700.00	990.71	.96	.75	0.00	118.17	400.00
6.000	22000.00	995.84	5.13	.72	0.00	387.37	400.00
7.000	3400.00	986.80	0.00	1.08	0.00	94.52	315.00
7.000	4300.00	987.69	.88	1.07	0.00	98.95	315.00
7.000	5900.00	989.03	1.34	1.11	0.00	105.63	315.00
7.000	7200.00	989.94	.91	1.21	0.00	111.42	315.00
7.000	8500.00	990.90	.96	1.15	0.00	116.69	315.00
7.000	9700.00	991.78	.88	1.07	0.00	121.53	315.00
7.000	22000.00	997.40	5.62	1.56	0.00	604.52	315.00
7.400	3400.00	987.06	0.00	.25	0.00	94.32	80.00
7.400	4300.00	987.94	.88	.25	0.00	98.73	80.00
7.400	5900.00	989.28	1.34	.25	0.00	105.44	80.00
7.400	7200.00	990.20	.92	.26	0.00	110.04	80.00
7.400	8500.00	991.15	.95	.25	0.00	114.77	80.00
7.400	9700.00	992.01	.87	.23	0.00	119.11	80.00
7.400	22000.00	997.49	5.48	.09	0.00	697.40	80.00
7.500	3400.00	987.17	0.00	.12	0.00	93.87	70.00
7.500	4300.00	988.08	.90	.14	0.00	98.38	70.00
7.500	5900.00	989.45	1.37	.17	0.00	105.24	70.00
7.500	7200.00	990.40	.95	.20	0.00	109.98	70.00
7.500	8500.00	991.36	.96	.21	0.00	114.79	70.00
7.500	9700.00	992.23	.87	.22	0.00	119.14	70.00
7.500	22000.00	997.33	5.10	-.16	0.00	650.71	70.00
8.000	3400.00	987.32	0.00	.15	0.00	92.16	50.00
8.000	4300.00	988.22	.90	.14	0.00	96.63	50.00
8.000	5900.00	989.59	1.37	.14	0.00	103.43	50.00
8.000	7200.00	990.54	.96	.15	0.00	111.82	50.00
8.000	8500.00	991.50	.96	.14	0.00	117.10	50.00
8.000	9700.00	992.37	.87	.14	0.00	121.89	50.00
8.000	22000.00	997.51	5.14	.18	0.00	324.66	50.00
9.000	3400.00	988.68	0.00	1.36	0.00	92.92	400.00
9.000	4300.00	989.57	.88	1.35	0.00	97.34	400.00
9.000	5900.00	990.95	1.39	1.37	0.00	105.74	400.00
9.000	7200.00	991.93	.98	1.39	0.00	111.14	400.00
9.000	8500.00	992.84	.91	1.34	0.00	116.14	400.00
9.000	9700.00	993.65	.80	1.27	0.00	120.56	400.00
9.000	22000.00	999.12	5.47	1.61	0.00	410.14	400.00

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
10.000	3400.00	989.91	0.00	1.23	0.00	113.96	380.00
10.000	4300.00	990.84	.93	1.27	0.00	119.56	380.00
10.000	5900.00	992.31	1.46	1.35	0.00	128.45	380.00
10.000	7200.00	993.34	1.04	1.41	0.00	134.73	380.00
10.000	8500.00	994.29	.95	1.45	0.00	140.51	380.00
10.000	9700.00	995.12	.83	1.48	0.00	145.54	380.00
10.000	22000.00	1001.01	5.89	1.89	0.00	453.29	380.00
10.500	3400.00	990.16	0.00	.25	0.00	112.99	135.00
10.500	4300.00	991.09	.93	.25	0.00	118.63	135.00
10.500	5900.00	992.54	1.46	.24	0.00	127.46	135.00
10.500	7200.00	993.57	1.03	.23	0.00	133.72	135.00
10.500	8500.00	994.52	.95	.23	0.00	139.47	135.00
10.500	9700.00	995.35	.82	.23	0.00	144.47	135.00
10.500	22000.00	1001.22	5.87	.21	0.00	350.13	135.00
11.000	3400.00	990.61	0.00	.45	0.00	102.30	230.00
11.000	4300.00	991.64	1.03	.55	0.00	153.44	230.00
11.000	5900.00	993.07	1.43	.53	0.00	162.04	230.00
11.000	7200.00	994.12	1.05	.55	0.00	168.33	230.00
11.000	8500.00	995.09	.97	.57	0.00	174.16	230.00
11.000	9700.00	995.93	.84	.59	0.00	179.21	230.00
11.000	22000.00	1002.08	6.15	.86	0.00	298.36	230.00
12.000	3400.00	991.52	0.00	.91	0.00	104.13	325.00
12.000	4300.00	992.82	1.30	1.18	0.00	156.95	325.00
12.000	5900.00	994.00	1.18	.93	0.00	164.01	325.00
12.000	7200.00	994.92	.92	.80	0.00	169.53	325.00
12.000	8500.00	995.80	.88	.71	0.00	174.81	325.00
12.000	9700.00	996.58	.78	.65	0.00	179.44	325.00
12.000	22000.00	1002.55	5.97	.47	0.00	349.36	325.00
13.000	3400.00	991.88	0.00	.36	0.00	104.49	150.00
13.000	4300.00	993.22	1.34	.40	0.00	158.13	150.00
13.000	5900.00	994.37	1.15	.37	0.00	165.09	150.00
13.000	7200.00	995.26	.89	.34	0.00	170.40	150.00
13.000	8500.00	996.12	.86	.32	0.00	175.51	150.00
13.000	9700.00	996.88	.76	.30	0.00	184.79	150.00
13.000	22000.00	1002.99	6.10	.44	0.00	573.95	150.00
14.000	3400.00	992.49	0.00	.61	0.00	105.16	265.00
14.000	4300.00	993.84	1.35	.62	0.00	158.26	265.00
14.000	5900.00	994.97	1.12	.59	0.00	165.04	265.00
14.000	7200.00	995.83	.86	.56	0.00	170.22	265.00
14.000	8500.00	996.65	.82	.53	0.00	175.15	265.00
14.000	9700.00	997.39	.74	.51	0.00	179.60	265.00
14.000	22000.00	1003.45	6.06	.47	0.00	1064.56	265.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	15.000	3400.00	993.50	0.00	1.01	0.00	105.80	475.00
	15.000	4300.00	994.88	1.37	1.03	0.00	159.05	475.00
	15.000	5900.00	995.98	1.11	1.02	0.00	165.69	475.00
	15.000	7200.00	996.82	.83	.99	0.00	170.75	475.00
	15.000	8500.00	997.61	.79	.95	0.00	175.44	475.00
	15.000	9700.00	998.31	.70	.92	0.00	179.69	475.00
	15.000	22000.00	1004.13	5.82	.68	0.00	904.61	475.00
	16.000	3400.00	994.12	0.00	.62	0.00	105.96	305.00
	16.000	4300.00	995.49	1.38	.62	0.00	159.16	305.00
	16.000	5900.00	996.60	1.11	.62	0.00	165.87	305.00
	16.000	7200.00	997.42	.82	.61	0.00	170.79	305.00
	16.000	8500.00	998.21	.78	.60	0.00	175.47	305.00
	16.000	9700.00	998.89	.69	.58	0.00	244.90	305.00
	16.000	22000.00	1004.33	5.44	.20	0.00	781.80	305.00
	17.000	3400.00	994.34	0.00	.23	0.00	106.61	105.00
	17.000	4300.00	995.72	1.38	.23	0.00	159.87	105.00
	17.000	5900.00	996.83	1.11	.23	0.00	166.53	105.00
	17.000	7200.00	997.65	.82	.23	0.00	171.53	105.00
	17.000	8500.00	998.43	.78	.23	0.00	176.20	105.00
	17.000	9700.00	999.11	.68	.22	0.00	180.29	105.00
	17.000	22000.00	1004.44	5.33	.11	0.00	1049.72	105.00
	18.000	3400.00	994.98	0.00	.64	0.00	106.36	340.00
	18.000	4300.00	996.36	1.37	.64	0.00	159.54	340.00
	18.000	5900.00	997.47	1.12	.64	0.00	166.29	340.00
	18.000	7200.00	998.29	.82	.64	0.00	171.22	340.00
	18.000	8500.00	999.07	.77	.63	0.00	175.85	340.00
	18.000	9700.00	999.74	.67	.63	0.00	196.62	340.00
	18.000	22000.00	1004.47	4.73	.03	0.00	756.81	340.00
	19.000	3400.00	995.95	0.00	.97	0.00	106.67	505.00
	19.000	4300.00	997.32	1.37	.97	0.00	159.91	505.00
	19.000	5900.00	998.44	1.12	.97	0.00	166.62	505.00
	19.000	7200.00	999.27	.82	.97	0.00	171.56	505.00
	19.000	8500.00	1000.03	.77	.96	0.00	176.15	505.00
	19.000	9700.00	1000.70	.67	.96	0.00	180.14	505.00
	19.000	22000.00	1005.59	4.89	1.12	0.00	1146.40	505.00
*	19.100	3400.00	996.37	0.00	.42	0.00	109.90	135.00
*	19.100	4300.00	997.59	1.22	.27	0.00	109.91	135.00
*	19.100	5900.00	998.67	1.08	.23	0.00	109.93	135.00
*	19.100	7200.00	999.44	.77	.17	0.00	109.94	135.00
	19.100	8500.00	1000.18	.75	.15	0.00	109.95	135.00
	19.100	9700.00	1000.83	.64	.13	0.00	109.96	135.00
	19.100	22000.00	1005.16	4.34	-.43	0.00	966.75	135.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	19.200	3400.00	996.40	0.00	.03	0.00	109.90	35.00
	19.200	4300.00	997.62	1.22	.03	0.00	109.91	35.00
	19.200	5900.00	998.73	1.10	.05	0.00	109.93	35.00
	19.200	7200.00	999.51	.79	.07	0.00	109.94	35.00
	19.200	8500.00	1000.28	.77	.10	0.00	109.95	35.00
	19.200	9700.00	1000.94	.66	.12	0.00	109.96	35.00
*	19.200	22000.00	1006.96	6.01	1.79	0.00	1673.59	35.00
	19.300	3400.00	996.42	0.00	.02	0.00	109.89	40.00
	19.300	4300.00	997.65	1.22	.02	0.00	109.90	40.00
	19.300	5900.00	998.75	1.11	.03	0.00	109.92	40.00
	19.300	7200.00	999.54	.79	.03	0.00	109.93	40.00
	19.300	8500.00	1000.32	.77	.04	0.00	109.94	40.00
	19.300	9700.00	1000.98	.67	.04	0.00	109.95	40.00
	19.300	22000.00	1006.58	5.60	-.37	0.00	1210.13	40.00
	19.400	3400.00	996.45	0.00	.03	0.00	109.89	40.00
	19.400	4300.00	997.68	1.23	.03	0.00	109.90	40.00
	19.400	5900.00	998.81	1.13	.05	0.00	109.92	40.00
	19.400	7200.00	999.62	.81	.07	0.00	109.93	40.00
	19.400	8500.00	1000.41	.79	.09	0.00	109.94	40.00
	19.400	9700.00	1001.10	.69	.11	0.00	109.95	40.00
	19.400	22000.00	1006.58	5.49	.00	0.00	1209.44	40.00
*	20.000	3400.00	996.48	0.00	.03	0.00	106.27	135.00
*	20.000	4300.00	997.76	1.28	.08	0.00	158.99	135.00
*	20.000	5900.00	998.93	1.17	.12	2.45	165.94	135.00
*	20.000	7200.00	999.78	.85	.16	3.30	174.84	135.00
	20.000	8500.00	1000.67	.89	.26	4.19	211.24	135.00
	20.000	9700.00	1001.54	.88	.45	5.07	963.34	135.00
*	20.000	22000.00	1008.93	7.38	2.34	12.45	2068.48	135.00

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                                                                          THIS RUN EXECUTED 04/22/92    17:23:36
**************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.0;  February 1991
**************************************

T1      ROCHESTER FLOOD CONTROL PROJECT - BEAR CREEK
T2      5 year event
T3      DM 6-DESIGN

J1  ICHECK    INQ     NINV    IDIR     STRT    METRIC   HVINS    Q       WSEL     FQ

               2                                                         994.98

J2  NPROF    IPLOT    PRFVS   XSECV    XSECH    FN      ALLDC    IBW     CHNIM    ITRACE

     1                 -1


J5  LPRNT   NUMSEC                   ********REQUESTED SECTION NUMBERS********

    -10      -10

NC     .050      .200      .035       .1        .3
QT       7.      3400      4300      5900      7200      8500      9700      22000
          ROCHESTER FLOOD CONTROL PROJECT - BEAR CREEK - UPPER REACH
          ************************************************************

          This model has the following features:
              A. U/S Drop Stucture 850 ft U/S of Highway 14
              B. cross sections from existing conditions file used
                 upstream of drop structure
              C. SCS reservoirs are assumed in place
              D. Tie-back levee information
                   1) Overflow structure and drop structure combined have a
                      capacity of 17,500 cfs
                   2) 17,500 cfs corresponds to 2500-yr event
                   3) Has 2 ft of freeboard above the design event
              E. Drop Structure passes design event
              F. High flow bench is 7 ft above invert & is 22.5 ft wide
              G. Low flow channel is 65 ft wide
              H. Model begins at Station 55+30
                   1) Starting water surface elev. taken from Lower Reach run

          **************************************************************
          STATION 55+30  Low Flow              BW=65     SS=1:3
                         High Flow             bw=22.5   SS=1:3
X1    18.000        21    10062.0   10242.0         0         0         0
GR    1012.5    9010.0    1012.00    9155.0   1010.00    9260.0   1008.00    9360.0   1006.00    9390.0
GR    1004.0    9815.0    1000.60   10062.0    993.20   10084.0    993.20   10114.0    988.10   10129.0
GR     988.1   10179.0     993.20   10194.0    993.20   10224.0    999.20   10242.0   1001.10   10300.0
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GR	1002.3	10450.0	1004.70	10475.0	1006.30	10700.0	1008.00	10930.0	1010.00	11105.0

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                                                                      THIS RUN EXECUTED 04/22/92    17:23:36
 ***************************************
  HEC-2 WATER SURFACE PROFILES

  Version   4.6.0;  February 1991
 ***************************************


 T1     ROCHESTER FLOOD CONTROL PROJECT - BEAR CREEK
 T2     5 year event
 T3     DM 6-DESIGN

 J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC    HVINS     Q        WSEL      FQ

                 2                                                           994.98

 J2  NPROF     IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC     IBW      CHNIM     ITRACE

       1                  -1


 J5  LPRNT    NUMSEC                ********REQUESTED SECTION NUMBERS********

     -10       -10

 NC     .050      .200      .035        .1         .3
 QT       7.      3400      4300      5900       7200       8500       9700      22000
          ROCHESTER FLOOD CONTROL PROJECT - BEAR CREEK - UPPER REACH
          *************************************************************

          This model has the following features:
              A. U/S Drop Stucture 850 ft U/S of Highway 14
              B. cross sections from existing conditions file used
                 upstream of drop structure
              C. SCS reservoirs are assumed in place
              D. Tie-back levee information
                   1) Overflow structure and drop structure combined have a
                      capacity of 17,500 cfs
                   2) 17,500 cfs corresponds to 2500-yr event
                   3) Has 2 ft of freeboard above the design event
              E. Drop Structure passes design event
              F. High flow bench is 7 ft above invert & is 22.5 ft wide
              G. Low flow channel is 65 ft wide
              H. Model begins at Station 55+30
                   1) Starting water surface elev. taken from Lower Reach run

          ***************************************************************
          STATION 55+30  Low Flow                 BW=65    SS=1:3
                         High Flow                bw=22.5  SS=1:3
 X1   18.000        21   10062.0   10242.0         0         0         0
 GR   1012.5    9010.0   1012.00    9155.0   1010.00    9260.0   1008.00    9360.0   1006.00    9390.0
 GR   1004.0    9815.0   1000.40   10062.0    993.20   10084.0    993.20   10114.0    988.10   10129.0
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GR 1002.3 10450.0 1004.70 10475.0 1006.30 10700.0 1008.00 10930.0 1010.00 11105.0

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GR  1011.4    11480.0

ET                                                                               9.1        9800       10800
         STATION 60+35  Begin Bridge Transition  BW=65    SS=1:3
                                                 bw=22.5  SS=1:3
X1  19.000        21    10250.0    10439.0       510        500        505
CI      -1     989.1        0.0          3         3        -65
CI      -1     996.1        0.0          3         3        152
GR  1013.0    8370.0    1012.00     8520.0   1010.00     8880.0    1010.00     9000.0    1008.00     9170.0
GR  1006.0    9335.0    1006.00     9510.0   1004.20     9950.0    1003.80    10033.0    1001.50    10050.0
GR  1001.0   10250.0     990.50    10282.0    990.50    10289.0     989.20    10293.0     989.20    10389.0
GR   990.5   10393.0     990.50    10400.0   1003.60    10439.0    1006.00    10820.0    1010.00    11180.0
GR  1010.3   11750.0

NC   .0500    .05000     .03000     .30000    .50000
         STATION 61+70 D/S face US HWY 14 BRIDGE - MNDOT DESIGN USED
                                                 BW=110   SS=vert.
X1  19.100        11    10270.0    10380.0       135        135        135
CI                                                          .01
CI                                                          .01
X3     10.                                                                   1004.10    1004.10
GR  1012.0    8500.0    1006.00     9500.0   1004.30     9950.0    1004.00    10020.0    1004.10    10270.0
GR   989.4   10270.1     989.40    10379.9   1004.10    10380.0    1004.30    10480.0    1006.00    10890.0
GR  1010.0   11400.0

NC   .0500    .05000     .03000     .30000    .50000
ET                                                                               9.1        9400       10800
SB   1.250      1.56       3.00       0.00    110.00       4.00    1570.00      0.000     989.45      989.4
X1  19.200         0          0          0        35         35         35
X2      0.      0.00         1.    1004.10   1006.00       0.00                 0.000                 0.000
X3     10.                                                                    1006.0     1006.0
BT     -10    8500.0    1012.00       0.00    9500.0    1006.00       0.00     9950.0    1007.10       0.00
BT       0   10270.0    1007.10       0.00   10380.0    1007.10       0.00    10430.0    1007.10       0.00
BT       0   10680.0    1007.20       0.00   10780.0    1007.40       0.00    10850.0    1008.00       0.00
BT       0   11400.0    1010.00       0.00

ET                                                                               9.1        9400       10800
X1  19.300         8      10270      10380        40         40         40
X3     10.                                                                    1006.0     1006.0
GR  1012.0    8500.0    1006.00     9500.0   1005.40    10270.0     989.50    10270.1     989.50    10379.9
GR  1005.4   10380.0    1008.00    10890.0   1010.00    11400.0

ET                                                                               9.1        9400       10800
SB   1.250      1.56       3.00       0.00    110.00       4.00    1570.00      0.000     989.60     989.50
         STATION 62+80 D/S face US HWY 14 BRIDGE - NO MOD. SCHEDULED
                            Begin transition from bridge to high/low flow
                                                 BW=110   SS=vert.
X1  19.400         0          0          0      40.0       40.0       40.0
X2      0.      0.00         1.    1005.40   1006.00       0.00                 0.000                 0.000
X3     10.                                                                   1006.00    1006.00
BT      -7    8500.0    1012.00       0.00    9500.0    1006.00       0.00    10270.0    1007.20       0.00
BT       0   10380.0    1007.30       0.00   10645.0    1007.40       0.00    10890.0      1008.       0.00
BT       0   11400.0    1010.00       0.00
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NC    .0500     .05000    .03500    .30000    .50000
ET                 9.1       9.1       9.1       9.1       9.1       9.1       9.1      9000     11400
           STATION 64+15 End of Bridge Transition  BW=65     SS=1:3
                                                bw=22.5   SS=1:3
X1    20.0        79     10750     10900       135       135       135
CI      -1     996.9       0.0         3         3       152
X3      10                                                                1002      1002
GR  1008.0    8440.0   1010.00    8610.0   1013.80    8820.0   1013.90    8930.0   1010.00    9160.0
GR  1008.0    9480.0   1007.00    9680.0   1006.00    9800.0   1006.00    9900.0   1004.00    9925.0
GR  1002.9   10000.0   1003.80   10025.0   1003.90   10029.0   1003.50   10050.0   1003.50   10075.0
GR  1003.8   10100.0   1003.70   10125.0   1003.10   10150.0   1003.00   10175.0   1002.70   10200.0
GR  1002.5   10225.0   1002.20   10250.0   1002.30   10275.0   1002.20   10300.0   1001.30   10318.0
GR  999.50   10329.0   1000.90   10339.0   1001.40   10350.0   1001.50   10375.0   1001.50   10400.0
GR  1001.2   10425.0   1000.70   10450.0   1001.00   10475.0   1001.00   10500.0   1000.80   10525.0
GR  1001.3   10675.0   1001.30   10700.0   1000.80   10725.0   1000.30   10750.0    999.50   10761.0
GR  996.40   10772.0    993.30   10775.0    993.10   10775.0    993.20   10785.0    989.90   10792.5
GR  989.90   10825.0    989.90   10857.5    994.80   10868.0    998.80   10883.0   1000.60   10900.0
GR  1001.6   11300.0   1001.60   11325.0   1002.30   11350.0   1003.60   11375.0   1004.51   11384.0
GR  1005.7   11400.0   1005.64   11413.0   1004.10   11425.0   1002.70   11434.0   1002.30   11450.0
GR  1002.6   11600.0   1002.50   11625.0   1002.90   11650.0   1003.00   11675.0   1003.10   11700.0
GR  1003.5   11725.0   1003.90   11750.0   1004.60   11775.0   1005.30   11800.0   1006.50   11825.0
GR  1007.0   11850.0   1007.70   11875.0   1008.30   11900.0   1008.90   11925.0   1009.20   11945.0
GR  1011.8   11956.0   1012.00   12055.0   1014.00   12170.0   1016.00   12475.0      0.00       0.0

ET                 9.1       9.1       9.1       9.1       9.1       9.1       9.1      9000     11500
NC    .0900     .09000    .03300    .30000    .50000
           STATION 69+10 Begin Transition to Drop Structure
                                                BW=65     SS=1:3
                                                bw=22.5   SS=1:3
X1      21        50   10850.0   11048.0       550       450       495
CI      -1     990.9       0.0         3         3       -65
CI      -1     997.9       0.0         3         3       152
X3      10                                                              1002.5    1002.5
GR  1013.4    7850.0   1012.00    8250.0   1012.00    8610.0   1010.00    8745.0   1010.30    8965.0
GR  1010.0    9335.0   1008.00    9445.0   1006.00    9630.0   1003.50    9800.0   1004.80   10020.0
GR  1004.0   10235.0   1003.00   10450.0   1002.00   10710.0   1002.00   10745.0   1002.50   10770.0
GR  1002.8   10825.0   1002.40   10850.0   1001.70   10855.0    993.62   10864.0    991.50   10864.0
GR  991.70   10874.0    992.50   10884.0    993.20   10894.0    993.40   10900.0    993.62   10900.0
GR  996.20   10906.0    999.10   10922.0    999.30   10925.0   1001.00   10950.0   1000.40   10975.0
GR  999.20   10991.0    998.80   11000.0    999.40   11014.0    996.70   11031.0   1003.10   11048.0
GR  1003.1   11050.0   1003.00   11075.0   1002.40   11100.0   1002.10   11125.0   1001.90   11150.0
GR  1001.8   11175.0   1002.00   11200.0   1002.00   11225.0   1001.90   11250.0   1001.00   11263.0
GR  1001.3   11276.0   1001.25   11288.0   1004.00   11540.0   1006.00   11650.0   1010.00   11810.0

           STATION 70+45 End of High Flow Bench    BW=110    SS=1:3
                                                bw=0      SS=1:3
X1    21.1         0         0         0       135       135       135
CI      -1     991.2       0.0         3         3      -110
CI                                                       .01
X3      10                                                              1003.5    1003.5
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          STATION 71+10 25-ft D/S of Drop Structure
                                    @ Elev 991.35  BW=132    SS=vertical
                                    @ Elev 997.0   BW=132    SS=1:3
X1     21.2         0         0         0        65        65        65
CI       -1    991.35       0.0         0         0      -132
CI       -1       997       0.0         3         3       132
X3       10                                                                  1003.5    1003.5

ET                9.1       9.1       9.1       9.1       9.1       9.1                 10510     11428
          STATION 71+35 D/S End of Drop Structure - 850 ft U/S of Hwy 14
              Weir Crest = 998.2 ft
              Weir Length = 140  ft
X1     21.3        29     10940     11080        25        25        25
CI                                                        .01
CI                                                        .01
X3       10
GR   1016.3    7480.0   1014.00    7945.0   1012.00    8305.0   1012.00    8350.0   1013.00    8520.0
GR   1012.0    8575.0   1010.00    8880.0   1008.00    9190.0   1008.00    9375.0   1007.50    9470.0
GR   1008.0    9790.0   1006.00    9955.0   1005.00   10175.0   1006.50   10420.0   1006.50   10570.0
GR   1006.5     10700    1006.5     10715    1006.5     10730    1006.5     10940     991.4     10940
GR    991.4     11080    1006.5     11080    1006.5     11420    1008.0     11570      1009     11650
GR     1010     11665      1012     11745      1014     11845    1016.5     11885

ET                9.1       9.1       9.1       9.1       9.1       9.1                 10510     11428
          STATION 71+67 U/S End of Drop Structure
X1     21.4        29     10940     11080        35        35        35
GR   1016.3    7480.0   1014.00    7945.0   1012.00    8305.0   1012.00    8350.0   1013.00    8520.0
GR   1012.0    8575.0   1010.00    8880.0   1008.00    9190.0   1008.00    9375.0   1007.50    9470.0
GR   1008.0    9790.0   1006.00    9955.0   1005.00   10175.0   1006.50   10420.0   1006.50   10570.0
GR   1006.5     10600    1006.5     10630    1006.5     10715    1006.5     10940     998.2     10940
GR    998.2     11080    1006.5     11080    1006.5     11420    1008.0     11570      1008     11650
GR     1010     11665      1012     11745      1014     11845    1016.5     11885

ET                9.1       9.1       9.1       9.1       9.1       9.1                 10820     11660
X1     21.5        58   11043.0   11175.0        25        25        25
CI       -1     995.2       0.0         3         3       140
X5        6    1002.2    1002.9    1004.0    1004.9    1005.6    1006.3
GR   1016.3    7480.0   1014.00    7945.0   1012.00    8305.0   1012.00    8350.0   1013.00    8520.0
GR   1012.0    8575.0   1010.00    8880.0   1008.00    9190.0   1008.00    9375.0   1007.50    9470.0
GR   1008.0    9790.0   1006.00    9955.0   1005.00   10175.0   1006.50   10420.0   1004.00   10570.0
GR   1002.5   10800.0   1001.30   10825.0   1000.80   10850.0   1000.80   10875.0   1001.10   10900.0
GR   1002.2   10925.0   1001.10   10950.0   1001.90   10975.0   1002.60   11000.0   1002.60   11025.0
GR   1002.9   11043.0    995.60   11055.0    993.99   11069.0    993.90   11069.0    993.30   11079.0
GR   993.30   11089.0    993.30   11099.0    993.10   11109.0    992.80   11114.0    993.99   11114.0
GR   1001.4   11124.0    999.80   11137.0   1000.00   11150.0   1000.30   11159.0   1003.20   11175.0
GR   1003.0   11200.0   1002.80   11225.0   1002.90   11250.0   1003.30   11268.0   1003.10   11275.0
GR   1002.9   11300.0   1002.80   11325.0   1002.77   11343.0   1004.50   11485.0   1006.00   11505.0
GR   1006.7   11550.0   1006.00   11620.0   1008.00   11650.0   1010.00   11665.0   1012.00   11745.0
GR   1014.0   11845.0   1016.00   11855.0   1016.50   11885.0
```

ET		9.1	9.1	9.1	9.1	9.1	9.1		10600	11650
	Existing conditions cross section									
X1	22	58	10850.0	11485.0	150	150	150			
CI	-1	995.2	0.0	3	3	140				
GR	1016.3	7480.0	1014.00	7945.0	1012.00	8305.0	1012.00	8350.0	1013.00	8520.0
GR	1012.0	8575.0	1010.00	8880.0	1008.00	9190.0	1008.00	9375.0	1007.50	9470.0
GR	1008.0	9790.0	1006.00	9955.0	1005.00	10175.0	1006.50	10420.0	1004.00	10570.0
GR	1002.5	10800.0	1001.30	10825.0	1000.80	10850.0	1000.80	10875.0	1001.10	10900.0
GR	1002.2	10925.0	1001.10	10950.0	1001.90	10975.0	1002.60	11000.0	1002.60	11025.0
GR	1002.9	11043.0	995.60	11055.0	993.99	11069.0	993.90	11069.0	993.30	11079.0
GR	993.30	11089.0	993.30	11099.0	993.10	11109.0	992.80	11114.0	993.99	11114.0
GR	1001.4	11124.0	999.80	11137.0	1000.00	11150.0	1000.30	11159.0	1003.20	11175.0
GR	1003.0	11200.0	1002.80	11225.0	1002.90	11250.0	1003.30	11268.0	1003.10	11275.0
GR	1002.9	11300.0	1002.80	11325.0	1002.77	11343.0	1004.50	11485.0	1006.00	11505.0
GR	1006.7	11550.0	1006.00	11620.0	1008.00	11650.0	1010.00	11665.0	1012.00	11745.0
GR	1014.0	11845.0	1016.00	11855.0	1016.50	11885.0				
ET		9.1	9.1	9.1	9.1	9.1	9.1		10350	11362
X1	23	97	10625	11342.0	350.0	750.0	1020.0			
CI						.01				
GR	1016.0	6530.0	1016.00	7360.0	1014.00	7380.0	1014.00	7940.0	1012.00	8135.0
GR	1012.0	8385.0	1010.00	8420.0	1011.00	8500.0	1010.00	8550.0	1009.50	8575.0
GR	1011.1	8650.0	1010.00	8700.0	1007.60	8730.0	1008.00	8750.0	1008.00	8905.0
GR	1010.0	8935.0	1010.00	9000.0	1008.00	9055.0	1007.00	9120.0	1008.00	9180.0
GR	1010.0	9345.0	1010.00	9600.0	1008.00	9800.0	1006.00	9930.0	1005.10	9975.0
GR	1005.4	10000.0	1005.50	10003.0	1005.67	10026.0	1005.69	10050.0	1005.61	10075.0
GR	1005.6	10100.0	1005.60	10125.0	1005.68	10150.0	1005.71	10175.0	1005.63	10188.0
GR	1004.9	10200.0	1004.10	10212.0	1004.00	10225.0	1003.90	10250.0	1003.70	10275.0
GR	1004.3	10300.0	1005.10	10311.0	1001.00	10320.0	1000.70	10325.0	1001.80	10350.0
GR	1003.7	10500.0	1003.60	10525.0	1003.40	10550.0	1003.20	10575.0	1003.00	10600.0
GR	1003.7	10625.0	1000.40	10650.0	999.10	10675.0	999.70	10700.0	999.70	10725.0
GR	1001.5	10750.0	1002.00	10775.0	1001.10	10800.0	1000.70	10807.0	995.50	10825.0
GR	994.59	10830.0	994.30	10832.0	993.90	10842.0	993.50	10852.0	993.90	10860.0
GR	994.59	10860.0	1003.40	10871.0	1003.30	10875.0	1003.10	10900.0	1002.54	10909.0
GR	1001.8	10925.0	1002.50	10950.0	1002.90	10975.0	1002.20	11000.0	1002.10	11025.0
GR	1001.0	11050.0	1002.50	11075.0	1003.20	11100.0	1002.90	11125.0	1003.00	11150.0
GR	1004.4	11300.0	1005.40	11325.0	1007.40	11342.0	1015.80	11362.0	1016.60	11375.0
GR	1017.0	11400.0	1016.70	11425.0	1016.50	11450.0	1016.80	11475.0	1016.50	11500.0
GR	1016.5	11525.0	1016.10	11550.0	1015.90	11555.0	1014.00	11568.0	1013.90	11581.0
GR	1016.9	11597.0	1020.00	11725.0						
ET		9.1	9.1	9.1	9.1	9.1	9.1		10520	12100
X1	24	97	10675.0	11350.0	680.0	670.0	755.0			
GR	1020.0	6950.0	1018.00	7390.0	1016.00	7535.0	1013.50	7600.0	1014.00	7630.0
GR	1016.0	7820.0	1016.80	7850.0	1014.00	7920.0	1014.00	7980.0	1015.00	8050.0
GR	1012.0	8250.0	1014.50	8325.0	1012.00	8520.0	1013.00	8625.0	1010.00	8700.0
GR	1012.3	9120.0	1010.00	9180.0	1008.30	9430.0	1008.00	9585.0	1007.00	9800.0
GR	1007.5	10000.0	1006.70	10025.0	1007.00	10050.0	1007.20	10075.0	1007.30	10100.0
GR	1004.4	10500.0	1004.20	10525.0	1004.20	10550.0	1004.30	10575.0	1004.20	10600.0
GR	1003.9	10625.0	1003.60	10650.0	1004.20	10675.0	1003.90	10700.0	1002.70	10725.0
GR	1003.7	10750.0	1003.70	10775.0	1004.00	10800.0	1004.20	10825.0	1003.90	10847.0
GR	1003.7	10850.0	1001.80	10875.0	1001.40	10881.0	1003.40	10900.0	1004.10	10907.0
GR	1004.2	10925.0	1003.70	10943.0	1001.80	10950.0	997.40	10960.0	999.50	10969.0

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GR   996.80   10975.0    994.79   10979.0    994.30   10979.0    994.00   10989.0    993.90   10999.0
GR   994.60   11009.0    994.60   11012.0    994.79   11012.0   1000.80   11019.0   1001.50   11025.0
GR   1002.7   11050.0   1002.90   11075.0   1002.95   11078.0   1003.27   11086.0   1003.40   11100.0
GR   1003.6   11125.0   1004.10   11132.0   1002.50   11150.0    999.50   11175.0    998.30   11186.0
GR   998.80   11196.0    999.70   11200.0   1002.90   11214.0   1003.40   11225.0   1004.00   11250.0
GR   1004.9   11275.0   1004.90   11300.0   1005.00   11325.0   1005.50   11350.0   1005.40   11375.0
GR   1005.0   11400.0   1005.50   11425.0   1005.80   11450.0   1004.50   11475.0   1005.40   11500.0
GR   1009.4   11600.0   1009.30   11625.0   1009.30   11650.0   1009.30   11675.0   1009.50   11700.0
GR   1012.6   11950.0   1012.30   11975.0   1012.30   12000.0   1012.70   12005.0   1017.89   12017.0
GR   1018.0   12115.0   1020.00   12240.0      0.00       0.0      0.00       0.0      0.00       0.0

ET                9.1       9.1       9.1       9.1       9.1       9.1                 10260     12020
         Upstream end of High School
X1       25        90     10400     11325     500.0     600.0     910.0      0.00      0.00         0
X2            1009.81
GR   1015.7    7500.0   1013.80    7930.0   1015.60    7960.0   1014.00    8185.0   1015.10    8300.0
GR   1013.0    8400.0   1012.00    8510.0   1013.50    8620.0   1012.00    8780.0   1012.50    8900.0
GR   1012.0    8945.0   1010.00    9225.0   1010.00    9325.0   1010.90    9400.0   1008.00    9900.0
GR   1007.1   10000.0   1006.80   10025.0   1006.90   10037.0   1007.00   10050.0   1006.82   10075.0
GR   1006.7   10100.0   1006.31   10120.0   1006.20   10125.0   1005.30   10150.0   1005.60   10175.0
GR   1006.7   10325.0   1006.50   10350.0   1006.60   10375.0   1006.80   10400.0   1005.80   10419.0
GR   1003.4   10425.0    998.30   10435.0    995.87   10435.0    994.80   10435.0    994.70   10445.0
GR   994.90   10455.0    995.20   10465.0    995.50   10471.0    995.87   10471.0    997.30   10475.0
GR   1000.3   10487.0   1002.10   10500.0   1003.20   10525.0   1003.10   10550.0   1003.90   10575.0
GR   1005.6   10600.0   1004.70   10625.0   1004.84   10629.0   1004.78   10644.0   1004.50   10650.0
GR   1004.7   10675.0   1005.00   10700.0   1004.70   10725.0   1003.80   10750.0   1001.70   10758.0
GR   1001.6   10775.0   1001.80   10800.0   1002.90   10808.0   1002.00   10825.0    999.80   10850.0
GR   1000.3   10864.0   1003.70   10875.0   1002.80   10900.0    999.10   10910.0    998.40   10925.0
GR   1000.4   10950.0   1004.50   10969.0   1004.90   10975.0   1005.10   11000.0   1005.30   11025.0
GR   1005.5   11050.0   1005.90   11075.0   1005.90   11100.0   1005.00   11125.0   1003.90   11150.0
GR   1005.3   11300.0   1005.70   11325.0   1006.80   11350.0   1008.50   11375.0   1009.90   11400.0
GR   1010.3   11425.0   1010.40   11450.0   1010.40   11475.0   1010.40   11500.0   1010.40   11525.0
GR   1010.0   11785.0   1012.00   11865.0   1016.00   11940.0   1018.00   11960.0   1020.00   12020.0

NC      .10       .10      .035
         Upstream left bank levee tie back point
X1       26        86   10550.0   11075.0     690.0     700.0     800.0      0.00      0.00         0
GR   1019.0    7960.0   1018.00    8030.0   1016.00    8180.0   1015.00    8225.0   1016.00    8275.0
GR   1016.0    8360.0   1014.00    8510.0   1014.00    8685.0   1012.00    8850.0   1012.00    9065.0
GR   1010.0    9300.0   1009.00    9470.0   1009.40    9710.0   1010.00    9800.0   1010.00    9930.0
GR   1010.8   10000.0   1010.50   10025.0   1010.30   10035.0   1007.70   10050.0   1007.00   10058.0
GR   1005.6   10425.0   1005.60   10450.0   1005.40   10475.0   1005.60   10500.0   1006.10   10525.0
GR   1005.7   10550.0   1003.90   10575.0   1004.00   10600.0   1005.00   10625.0   1005.20   10650.0
GR   1005.2   10675.0   1003.80   10700.0   1001.60   10717.0   1001.80   10725.0   1004.20   10750.0
GR   1003.4   10763.0   1001.40   10775.0   1003.10   10795.0    996.50   10800.0    995.70   10800.0
GR   995.00   10810.0    994.70   10820.0    995.70   10830.0    996.10   10840.0    995.50   10850.0
GR   995.90   10860.0    996.00   10870.0    995.20   10875.0    996.50   10875.0   1001.80   10882.0
GR   1002.4   10900.0   1003.28   10925.0   1003.35   10933.0   1003.50   10950.0   1005.00   10975.0
GR   1003.5   11000.0   1002.80   11025.0    999.50   11047.0   1000.00   11050.0   1003.70   11075.0
GR   1004.3   11100.0   1007.00   11125.0   1008.30   11150.0   1007.60   11159.0   1006.60   11175.0
GR   1004.5   11189.0   1004.60   11200.0   1004.40   11225.0   1004.80   11250.0   1005.10   11275.0
GR   1006.9   11425.0   1007.10   11450.0   1007.10   11475.0   1007.90   11500.0   1007.90   11525.0
GR   1008.6   11550.0   1009.80   11575.0   1010.90   11600.0   1011.40   11625.0   1011.30   11650.0
GR   1010.0   12075.0   1012.00   12120.0   1014.00   12250.0   1016.00   12360.0   1018.00   12475.0
```

GR	1020.0	12575.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
X1	27	83	10457.0	10825.0	670.0	650.0	1110.0	0.00	0.00	0
GR	1020.0	8380.0	1018.00	8540.0	1016.00	9080.0	1014.00	9170.0	1012.00	9350.0
GR	1010.0	9735.0	1010.00	9780.0	1012.00	9800.0	1012.00	9835.0	1010.00	9890.0
GR	1009.9	10000.0	1009.60	10012.0	1007.90	10025.0	1007.40	10050.0	1007.40	10075.0
GR	1007.5	10100.0	1007.60	10125.0	1007.50	10150.0	1007.40	10175.0	1006.90	10200.0
GR	1006.3	10225.0	1005.90	10250.0	1005.80	10275.0	1005.50	10300.0	1005.10	10325.0
GR	1005.1	10350.0	1005.50	10375.0	1005.80	10400.0	1006.20	10425.0	1007.00	10450.0
GR	1007.9	10457.0	1005.70	10475.0	1004.60	10483.0	1005.50	10500.0	1006.80	10525.0
GR	1006.8	10550.0	1006.10	10575.0	1007.00	10600.0	1006.10	10623.0	1005.70	10625.0
GR	1004.5	10633.0	1006.10	10650.0	1005.30	10675.0	1004.50	10691.0	1003.30	10700.0
GR	1001.9	10721.0	999.40	10725.0	997.70	10732.0	997.30	10742.0	996.40	10752.0
GR	996.70	10762.0	997.70	10762.0	1005.80	10775.0	1007.10	10800.0	1006.33	10809.0
GR	1006.5	10816.0	1007.30	10825.0	1008.30	10850.0	1009.30	10875.0	1010.60	10900.0
GR	1010.2	10925.0	1010.90	10950.0	1011.90	10967.0	1010.40	10975.0	1004.80	11000.0
GR	1003.5	11009.0	1004.90	11025.0	1005.50	11045.0	1005.50	11050.0	1005.20	11075.0
GR	1007.1	11350.0	1007.60	11375.0	1008.20	11400.0	1009.00	11425.0	1010.20	11450.0
GR	1012.0	12070.0	1010.90	12210.0	1012.00	12285.0	1014.00	12630.0	1016.00	12650.0
GR	1016.5	12800.0	1016.00	12945.0	1020.00	13000.0	0.00	0.0	0.00	0.0
X1	28	81	10259.0	10975.0	520.0	420.0	920.0	0.00	0.00	0
GR	1020.0	8810.0	1018.00	8980.0	1016.60	9210.0	1016.00	9270.0	1014.00	9725.0
GR	1012.6	9775.0	1014.00	9830.0	1014.00	9874.9	1014.00	9875.0	1012.00	9900.0
GR	1011.2	10000.0	1011.20	10016.0	1010.30	10025.0	1010.40	10050.0	1010.10	10075.0
GR	1010.0	10225.0	1008.20	10250.0	1008.30	10259.0	1006.80	10273.0	1006.90	10275.0
GR	1007.5	10300.0	1007.40	10325.0	1007.60	10350.0	1006.70	10375.0	1006.90	10400.0
GR	1005.2	10410.0	1006.00	10422.0	1005.50	10425.0	999.24	10431.0	998.70	10431.0
GR	998.40	10441.0	998.50	10451.0	998.70	10461.0	998.80	10471.0	998.90	10474.0
GR	999.24	10474.0	1000.30	10476.0	1006.60	10482.0	1006.90	10500.0	1006.34	10514.0
GR	1006.4	10522.0	1007.60	10525.0	1007.00	10550.0	1007.20	10575.0	1006.70	10600.0
GR	1005.3	10617.0	1005.40	10625.0	1005.00	10650.0	1005.00	10675.0	1006.50	10700.0
GR	1003.5	10719.0	1003.50	10725.0	1003.40	10747.0	1004.40	10750.0	1006.10	10769.0
GR	1006.1	10775.0	1006.70	10800.0	1007.00	10825.0	1006.80	10850.0	1007.10	10875.0
GR	1007.7	10900.0	1007.80	10925.0	1007.80	10950.0	1008.90	10975.0	1009.50	11000.0
GR	1010.0	11025.0	1009.60	11050.0	1008.20	11075.0	1008.00	11100.0	1007.30	11125.0
GR	1009.0	11275.0	1009.50	11300.0	1010.00	11325.0	1010.40	11350.0	1010.37	11359.0
GR	1011.5	11580.0	1012.00	11800.0	1014.00	12660.0	1016.00	12740.0	1018.00	13065.0
GR	1020.0	13075.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
X1	29	81	10725.0	11042.0	700.0	670.0	1425.0	0.00	0.00	0
GR	1022.0	9780.0	1020.00	9865.0	1018.00	9890.0	1016.00	9930.0	1015.00	9970.0
GR	1015.9	10000.0	1015.50	10005.0	1013.60	10016.0	1013.70	10025.0	1012.60	10050.0
GR	1013.3	10075.0	1012.70	10100.0	1012.40	10125.0	1012.10	10150.0	1012.00	10175.0
GR	1009.6	10575.0	1009.40	10600.0	1008.10	10625.0	1008.40	10650.0	1008.20	10669.0
GR	1004.6	10675.0	1002.70	10679.0	1006.60	10693.0	1007.10	10700.0	1009.10	10721.0
GR	1009.0	10725.0	1008.10	10734.0	1004.40	10740.0	1001.57	10742.0	1000.30	10742.0
GR	1000.4	10752.0	1000.30	10762.0	1000.80	10772.0	1000.90	10782.0	1000.90	10792.0
GR	1001.0	10802.0	1001.40	10812.0	1001.10	10822.0	1001.10	10832.0	1000.60	10842.0
GR	1000.7	10852.0	1000.80	10853.0	1001.57	10853.0	1009.10	10875.0	1008.00	10900.0
GR	1007.7	10925.0	1006.80	10950.0	1005.20	10962.0	1002.10	10972.0	1001.20	10972.0
GR	1000.4	10982.0	1000.80	10992.0	1000.60	11002.0	1000.30	11012.0	1000.70	11016.0
GR	1001.2	11016.0	1008.90	11023.0	1008.80	11025.0	1008.03	11042.0	1008.32	11050.0
GR	1008.4	11052.0	1008.20	11075.0	1008.40	11100.0	1008.90	11125.0	1009.70	11150.0

GR	1008.9	11175.0	1008.60	11180.0	1008.80	11200.0	1008.50	11225.0	1008.70	11250.0
GR	1008.9	11275.0	1008.90	11300.0	1009.70	11312.0	1009.62	11313.0	1009.90	11325.0
GR	1013.4	12170.0	1013.90	12900.0	1014.00	13010.0	1016.00	13230.0	1018.00	13400.0
GR	1020.0	13450.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
X1	30	35	10006.0	10535.0	450.0	450.0	715.0	0.00	0.00	0
GR	1022.0	8850.0	1020.00	9000.0	1018.00	9070.0	1018.00	9140.0	1014.00	9165.0
GR	1012.0	9220.0	1012.00	9350.0	1012.00	9500.0	1010.00	9620.0	1010.00	9690.0
GR	1008.5	10000.0	1008.70	10002.0	1008.40	10006.0	1003.60	10011.0	1006.40	10027.0
GR	1005.2	10049.0	1001.90	10054.0	1001.60	10055.0	1001.60	10065.0	1001.80	10075.0
GR	1001.9	10085.0	1004.80	10089.0	1006.80	10098.0	1007.20	10102.0	1008.60	10127.0
GR	1008.0	10425.0	1008.00	10535.0	1010.00	10735.0	1012.00	10825.0	1014.00	11235.0
GR	1014.0	11580.0	1016.00	12340.0	1018.00	12610.0	1020.00	12675.0	1022.00	12760.0
X1	31	36	9690.	10430.0	850.0	150.0	185.0	0.00	0.00	0
GR	1020.0	7650.0	1018.00	8000.0	1016.00	8260.0	1016.00	8370.0	1014.00	8440.0
GR	1014.0	8560.0	1012.00	9415.0	1010.00	9520.0	1008.00	9690.0	1007.10	9895.0
GR	1007.6	10000.0	1007.50	10025.0	1007.40	10050.0	1007.90	10075.0	1007.30	10084.0
GR	1002.8	10090.0	1001.60	10090.0	1002.10	10100.0	1001.70	10110.0	1002.30	10120.0
GR	1002.8	10121.0	1002.60	10121.0	1003.30	10123.0	1003.30	10125.0	1004.30	10135.0
GR	1008.0	10430.0	1010.00	10625.0	1012.00	10710.0	1012.70	10870.0	1014.00	11080.0
GR	1015.2	11510.0	1016.00	11670.0	1018.30	11950.0	1018.00	12445.0	1020.00	12620.0
GR	1022.0	12800.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0

DM 6-DESIGN

Starting profile number 1

T1 Rochester Flood Control Project - Bear Creek
T2 10 year event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		3							996.36	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2		-1							

DM 6 - Design

Starting profile number 2

T1 Rochester Flood Control Project - Bear Creek
T2 25 year event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		4							997.47	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	3		-1							

DM 6 - Design

Starting profile number 3

T1 Rochester Flood Control Project - Bear Creek
T2 50 year event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		5							998.30	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	4		-1							

DM 6 - Design

Starting profile number 4

T1 Rochester Flood Control Project - Bear Creek
T2 100 year event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		6							999.07	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	5		-1							

DM 6 - Design

Starting profile number 5

T1 Rochester Flood Control Project - Bear Creek
T2 Design Event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		7							999.75	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	6		-1							

DM 6 - Design

Starting profile number 6

T1 Rochester Flood Control Project - Bear Creek
T2 SPF Event
T3 DM 6 - Design

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		8							1004.50	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	7		-1							

DM 6 - Design

Starting profile number 7

THIS RUN EXECUTED 04/22/92 17:24:24

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.0; February 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

DM 6-DESIGN

SUMMARY PRINTOUT TABLE 150

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	18.000	0.00	0.00	0.00	988.10	3400.00	994.98	0.00	995.50	30.41	5.76	590.16	616.57
	18.000	0.00	0.00	0.00	988.10	4300.00	996.36	0.00	996.80	18.70	5.35	803.72	994.34
	18.000	0.00	0.00	0.00	988.10	5900.00	997.47	0.00	998.03	18.99	6.00	983.75	1353.86
	18.000	0.00	0.00	0.00	988.10	7200.00	998.30	0.00	998.94	18.94	6.41	1123.18	1654.52
	18.000	0.00	0.00	0.00	988.10	8500.00	999.07	0.00	999.78	18.85	6.77	1256.21	1957.61
	18.000	0.00	0.00	0.00	988.10	9700.00	999.75	0.00	1000.52	18.46	7.05	1380.79	2257.79
	18.000	0.00	0.00	0.00	988.10	22000.00	1004.50	0.00	1005.71	16.67	9.15	3497.58	5388.86
	19.000	505.00	0.00	0.00	989.10	3400.00	996.40	0.00	996.83	22.88	5.25	648.21	710.80
	19.000	505.00	0.00	0.00	989.10	4300.00	997.32	0.00	997.78	19.79	5.44	790.87	966.57
	19.000	505.00	0.00	0.00	989.10	5900.00	998.44	0.00	999.01	19.76	6.06	973.21	1327.39
	19.000	505.00	0.00	0.00	989.10	7200.00	999.27	0.00	999.92	19.66	6.48	1111.63	1623.65
	19.000	505.00	0.00	0.00	989.10	8500.00	1000.03	0.00	1000.75	19.52	6.83	1244.29	1923.78
	19.000	505.00	0.00	0.00	989.10	9700.00	1000.69	0.00	1001.48	19.38	7.12	1362.55	2203.64
	19.000	505.00	0.00	0.00	989.10	22000.00	1005.61	0.00	1006.51	14.05	8.18	3834.85	5869.65
*	19.100	135.00	0.00	0.00	989.40	3400.00	996.74	0.00	997.02	6.00	4.22	806.36	1388.04
*	19.100	135.00	0.00	0.00	989.40	4300.00	997.60	0.00	997.96	6.75	4.77	901.21	1655.42
*	19.100	135.00	0.00	0.00	989.40	5900.00	998.67	0.00	999.19	8.63	5.79	1018.80	2008.23
*	19.100	135.00	0.00	0.00	989.40	7200.00	999.44	0.00	1000.11	10.01	6.52	1103.46	2275.85
	19.100	135.00	0.00	0.00	989.40	8500.00	1000.19	0.00	1000.99	11.16	7.17	1185.28	2544.59
	19.100	135.00	0.00	0.00	989.40	9700.00	1000.83	0.00	1001.75	12.14	7.72	1255.74	2783.61
	19.100	135.00	0.00	0.00	989.40	22000.00	1005.17	1000.12	1007.41	21.13	12.23	2374.26	4785.60
	19.200	35.00	1006.00	1004.10	989.40	3400.00	996.77	0.00	997.04	5.93	4.20	809.19	1395.78
	19.200	35.00	1006.00	1004.10	989.40	4300.00	997.64	0.00	997.99	6.66	4.75	905.03	1666.53
	19.200	35.00	1006.00	1004.10	989.40	5900.00	998.73	0.00	999.25	8.47	5.76	1025.12	2027.83
	19.200	35.00	1006.00	1004.10	989.40	7200.00	999.52	0.00	1000.17	9.76	6.47	1112.22	2304.15
	19.200	35.00	1006.00	1004.10	989.40	8500.00	1000.29	0.00	1001.07	10.84	7.10	1196.38	2581.79
	19.200	35.00	1006.00	1004.10	989.40	9700.00	1000.95	0.00	1001.86	11.75	7.64	1269.27	2830.26
*	19.200	35.00	1006.00	1004.10	989.40	22000.00	1006.90	0.00	1007.96	10.35	9.18	4584.24	6838.95

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	19.300	40.00	0.00	0.00	989.50	3400.00	996.79	0.00	997.07	6.13	4.25	800.80	1372.86
	19.300	40.00	0.00	0.00	989.50	4300.00	997.66	0.00	998.02	6.85	4.79	896.95	1643.07
	19.300	40.00	0.00	0.00	989.50	5900.00	998.76	0.00	999.28	8.66	5.80	1017.83	2005.24
	19.300	40.00	0.00	0.00	989.50	7200.00	999.56	0.00	1000.22	9.95	6.51	1105.53	2282.51
	19.300	40.00	0.00	0.00	989.50	8500.00	1000.33	0.00	1001.12	11.02	7.14	1190.16	2560.90
	19.300	40.00	0.00	0.00	989.50	9700.00	1000.99	0.00	1001.91	11.91	7.68	1263.47	2810.20
	19.300	40.00	0.00	0.00	989.50	22000.00	1006.52	1000.23	1008.45	16.76	11.33	2653.09	5374.65
	19.400	40.00	1006.00	1005.40	989.50	3400.00	996.81	0.00	997.09	6.07	4.23	803.41	1379.97
	19.400	40.00	1006.00	1005.40	989.50	4300.00	997.70	0.00	998.05	6.76	4.78	900.50	1653.38
	19.400	40.00	1006.00	1005.40	989.50	5900.00	998.82	0.00	999.33	8.50	5.76	1023.78	2023.66
	19.400	40.00	1006.00	1005.40	989.50	7200.00	999.64	0.00	1000.29	9.72	6.47	1113.68	2308.86
	19.400	40.00	1006.00	1005.40	989.50	8500.00	1000.43	0.00	1001.21	10.72	7.08	1200.61	2596.01
	19.400	40.00	1006.00	1005.40	989.50	9700.00	1001.12	0.00	1002.01	11.55	7.60	1276.20	2854.25
	19.400	40.00	1006.00	1005.40	989.50	22000.00	1006.52	0.00	1008.45	16.77	11.34	2649.61	5371.97
*	20.000	135.00	0.00	0.00	989.90	3400.00	996.83	0.00	997.35	19.57	5.79	587.72	768.50
*	20.000	135.00	0.00	0.00	989.90	4300.00	997.76	0.00	998.30	25.81	5.90	728.81	846.44
*	20.000	135.00	0.00	0.00	989.90	5900.00	998.94	0.00	999.58	23.99	6.43	916.96	1204.52
*	20.000	135.00	0.00	0.00	989.90	7200.00	999.80	0.00	1000.51	22.95	6.79	1060.68	1503.09
	20.000	135.00	0.00	0.00	989.90	8500.00	1000.63	0.00	1001.41	21.77	7.06	1203.89	1821.75
	20.000	135.00	0.00	0.00	989.90	9700.00	1001.43	0.00	1002.24	19.69	7.22	1343.07	2186.10
*	20.000	135.00	0.00	0.00	989.90	22000.00	1008.97	0.00	1009.05	1.54	3.18	13028.87	17752.73
	21.000	495.00	0.00	0.00	990.90	3400.00	997.74	0.00	998.27	17.55	5.81	585.22	811.66
	21.000	495.00	0.00	0.00	990.90	4300.00	998.94	0.00	999.43	19.68	5.64	762.57	969.24
	21.000	495.00	0.00	0.00	990.90	5900.00	1000.04	0.00	1000.65	19.41	6.26	941.75	1339.18
	21.000	495.00	0.00	0.00	990.90	7200.00	1000.86	0.00	1001.55	19.15	6.68	1078.57	1645.27
	21.000	495.00	0.00	0.00	990.90	8500.00	1001.65	0.00	1002.41	18.78	7.01	1212.03	1961.51
	21.000	495.00	0.00	0.00	990.90	9700.00	1002.36	0.00	1003.17	18.12	7.24	1339.73	2279.00
*	21.000	495.00	0.00	0.00	990.90	22000.00	1009.03	0.00	1009.22	3.37	4.60	12740.66	11990.32
*	21.100	135.00	0.00	0.00	991.20	3400.00	998.28	0.00	998.49	6.04	3.66	929.86	1383.67
*	21.100	135.00	0.00	0.00	991.20	4300.00	999.40	0.00	999.64	5.78	3.89	1104.12	1788.27
*	21.100	135.00	0.00	0.00	991.20	5900.00	1000.56	0.00	1000.88	6.83	4.56	1292.75	2258.25
*	21.100	135.00	0.00	0.00	991.20	7200.00	1001.41	0.00	1001.80	7.47	5.02	1435.44	2633.58
*	21.100	135.00	0.00	0.00	991.20	8500.00	1002.21	0.00	1002.66	7.95	5.40	1574.60	3014.65
*	21.100	135.00	0.00	0.00	991.20	9700.00	1002.94	0.00	1003.44	8.94	5.67	1709.65	3243.94
	21.100	135.00	0.00	0.00	991.20	22000.00	1009.09	0.00	1009.26	2.61	4.33	13985.77	13622.57
	21.200	65.00	0.00	0.00	991.35	3400.00	998.39	0.00	998.54	4.40	3.16	1077.29	1620.26
	21.200	65.00	0.00	0.00	991.35	4300.00	999.51	0.00	999.69	4.21	3.37	1277.19	2095.77
	21.200	65.00	0.00	0.00	991.35	5900.00	1000.71	0.00	1000.95	4.92	3.94	1497.64	2660.28
	21.200	65.00	0.00	0.00	991.35	7200.00	1001.58	0.00	1001.87	5.36	4.33	1663.91	3111.01
	21.200	65.00	0.00	0.00	991.35	8500.00	1002.40	0.00	1002.74	5.68	4.66	1825.35	3567.42
	21.200	65.00	0.00	0.00	991.35	9700.00	1003.14	0.00	1003.52	5.78	4.92	1973.34	4033.07
	21.200	65.00	0.00	0.00	991.35	22000.00	1009.11	0.00	1009.28	2.25	4.20	14254.21	14681.87

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
	21.300	25.00	0.00	0.00	991.40	3400.00	998.38	0.00	998.57	5.06	3.47	978.63	1512.12
	21.300	25.00	0.00	0.00	991.40	4300.00	999.50	0.00	999.72	5.04	3.79	1133.92	1914.49
	21.300	25.00	0.00	0.00	991.40	5900.00	1000.68	0.00	1001.00	6.16	4.54	1299.22	2377.99
	21.300	25.00	0.00	0.00	991.40	7200.00	1001.54	0.00	1001.94	6.92	5.07	1419.40	2736.08
	21.300	25.00	0.00	0.00	991.40	8500.00	1002.35	0.00	1002.83	7.57	5.55	1532.69	3088.92
	21.300	25.00	0.00	0.00	991.40	9700.00	1003.08	0.00	1003.62	8.05	5.93	1634.52	3418.01
*	21.300	25.00	0.00	0.00	991.40	22000.00	1008.85	0.00	1009.56	7.82	7.44	7202.92	7867.60
*	21.400	35.00	0.00	0.00	998.20	3400.00	1000.83	1000.83	1002.15	122.17	9.25	367.74	307.61
*	21.400	35.00	0.00	0.00	998.20	4300.00	1001.27	1001.27	1002.82	116.89	10.00	430.08	397.73
*	21.400	35.00	0.00	0.00	998.20	5900.00	1001.99	1001.99	1003.91	110.47	11.11	530.93	561.34
*	21.400	35.00	0.00	0.00	998.20	7200.00	1002.54	1002.54	1004.72	106.07	11.85	607.44	699.09
*	21.400	35.00	0.00	0.00	998.20	8500.00	1003.04	1003.04	1005.48	103.69	12.55	677.44	834.72
*	21.400	35.00	0.00	0.00	998.20	9700.00	1003.48	1003.48	1006.15	101.62	13.12	739.49	962.21
*	21.400	35.00	0.00	0.00	998.20	22000.00	1008.59	1008.57	1009.92	29.87	10.88	5636.10	4025.51
*	21.500	25.00	0.00	0.00	992.80	3400.00	1002.20	0.00	1002.32	3.05	2.75	1365.12	1948.07
*	21.500	25.00	0.00	0.00	992.80	4300.00	1002.90	0.00	1003.05	3.47	3.10	1627.93	2307.43
*	21.500	25.00	0.00	0.00	992.80	5900.00	1004.00	0.00	1004.19	3.81	3.57	2255.99	3023.93
*	21.500	25.00	0.00	0.00	992.80	7200.00	1004.90	0.00	1005.10	3.74	3.79	2845.32	3722.68
*	21.500	25.00	0.00	0.00	992.80	8500.00	1005.60	0.00	1005.82	3.85	4.03	3317.78	4332.86
*	21.500	25.00	0.00	0.00	992.80	9700.00	1006.30	0.00	1006.53	3.77	4.17	3804.29	4996.42
*	21.500	25.00	0.00	0.00	992.80	22000.00	1010.09	0.00	1010.28	3.07	4.61	13658.94	12554.69
	22.000	150.00	0.00	0.00	992.80	3400.00	1002.31	0.00	1002.38	2.84	2.08	1670.81	2016.60
	22.000	150.00	0.00	0.00	992.80	4300.00	1003.05	0.00	1003.12	3.97	2.20	2034.54	2158.65
	22.000	150.00	0.00	0.00	992.80	5900.00	1004.20	0.00	1004.27	3.63	2.23	2924.82	3096.24
	22.000	150.00	0.00	0.00	992.80	7200.00	1005.12	0.00	1005.19	2.82	2.19	3734.38	4290.56
	22.000	150.00	0.00	0.00	992.80	8500.00	1005.84	0.00	1005.91	2.45	2.24	4381.12	5427.13
	22.000	150.00	0.00	0.00	992.80	9700.00	1006.55	0.00	1006.62	2.13	2.25	5048.23	6653.49
	22.000	150.00	0.00	0.00	992.80	22000.00	1010.25	0.00	1010.34	1.67	2.70	14409.12	17025.08
*	23.000	1020.00	0.00	0.00	993.50	3400.00	1002.86	0.00	1003.05	20.73	3.53	1002.86	746.73
*	23.000	1020.00	0.00	0.00	993.50	4300.00	1003.71	0.00	1003.84	14.36	2.99	1589.50	1134.71
*	23.000	1020.00	0.00	0.00	993.50	5900.00	1004.71	0.00	1004.82	8.45	2.72	2515.55	2029.12
*	23.000	1020.00	0.00	0.00	993.50	7200.00	1005.49	0.00	1005.59	5.80	2.58	3271.39	2989.06
	23.000	1020.00	0.00	0.00	993.50	8500.00	1006.15	0.00	1006.24	4.64	2.57	3916.68	3944.96
	23.000	1020.00	0.00	0.00	993.50	9700.00	1006.81	0.00	1006.90	3.76	2.52	4564.16	5004.60
	23.000	1020.00	0.00	0.00	993.50	22000.00	1010.42	0.00	1010.52	2.29	2.83	12621.01	14548.14
	24.000	755.00	0.00	0.00	993.90	3400.00	1004.26	0.00	1004.38	14.76	2.80	1241.75	885.07
	24.000	755.00	0.00	0.00	993.90	4300.00	1004.72	0.00	1004.85	12.40	2.88	1575.41	1220.96
	24.000	755.00	0.00	0.00	993.90	5900.00	1005.42	0.00	1005.55	10.94	2.99	2162.54	1783.99
	24.000	755.00	0.00	0.00	993.90	7200.00	1006.00	0.00	1006.13	8.62	2.99	2729.14	2452.30
	24.000	755.00	0.00	0.00	993.90	8500.00	1006.56	0.00	1006.69	7.09	3.00	3289.23	3191.34
	24.000	755.00	0.00	0.00	993.90	9700.00	1007.13	0.00	1007.26	5.76	2.96	3876.18	4041.74
	24.000	755.00	0.00	0.00	993.90	22000.00	1010.60	0.00	1010.72	3.03	3.12	12231.19	12639.04

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	25.000	910.00	0.00	0.00	994.70	3400.00	1005.16	0.00	1005.22	5.97	1.95	1744.87	1391.29
	25.000	910.00	0.00	0.00	994.70	4300.00	1005.59	0.00	1005.65	6.38	2.06	2084.33	1702.65
	25.000	910.00	0.00	0.00	994.70	5900.00	1006.21	0.00	1006.29	6.06	2.23	2642.74	2396.09
	25.000	910.00	0.00	0.00	994.70	7200.00	1006.68	0.00	1006.76	5.54	2.35	3096.44	3057.80
	25.000	910.00	0.00	0.00	994.70	8500.00	1007.14	0.00	1007.23	4.98	2.42	3603.02	3809.94
	25.000	910.00	0.00	0.00	994.70	9700.00	1007.63	0.00	1007.72	4.31	2.44	4134.61	4674.49
	25.000	910.00	0.00	0.00	994.70	22000.00	1010.85	0.00	1010.97	2.83	2.88	10396.61	13077.33
	26.000	800.00	0.00	0.00	994.70	3400.00	1005.56	0.00	1005.61	4.22	1.93	1882.12	1654.96
	26.000	800.00	0.00	0.00	994.70	4300.00	1006.00	0.00	1006.07	4.39	2.13	2259.20	2052.56
	26.000	800.00	0.00	0.00	994.70	5900.00	1006.63	0.00	1006.72	4.74	2.45	2941.40	2710.43
	26.000	800.00	0.00	0.00	994.70	7200.00	1007.08	0.00	1007.19	4.91	2.67	3518.20	3248.73
	26.000	800.00	0.00	0.00	994.70	8500.00	1007.52	0.00	1007.64	4.91	2.82	4131.24	3837.21
	26.000	800.00	0.00	0.00	994.70	9700.00	1007.97	0.00	1008.09	4.67	2.91	4768.17	4486.89
	26.000	800.00	0.00	0.00	994.70	22000.00	1011.09	0.00	1011.26	4.21	3.69	10882.64	10719.01
*	27.000	1110.00	0.00	0.00	996.40	3400.00	1006.43	0.00	1006.74	34.01	4.65	1051.83	582.97
*	27.000	1110.00	0.00	0.00	996.40	4300.00	1006.94	0.00	1007.20	36.73	4.45	1465.75	709.55
*	27.000	1110.00	0.00	0.00	996.40	5900.00	1007.56	0.00	1007.81	28.75	4.50	2104.55	1100.29
*	27.000	1110.00	0.00	0.00	996.40	7200.00	1007.99	0.00	1008.25	25.15	4.61	2618.02	1435.77
*	27.000	1110.00	0.00	0.00	996.40	8500.00	1008.39	0.00	1008.65	22.47	4.71	3110.77	1793.05
*	27.000	1110.00	0.00	0.00	996.40	9700.00	1008.77	0.00	1009.03	20.06	4.75	3586.88	2165.71
*	27.000	1110.00	0.00	0.00	996.40	22000.00	1011.69	0.00	1011.97	12.28	5.35	8627.46	6277.30
*	28.000	920.00	0.00	0.00	998.40	3400.00	1008.17	0.00	1008.24	9.30	2.19	1597.14	1115.10
*	28.000	920.00	0.00	0.00	998.40	4300.00	1008.55	0.00	1008.64	8.66	2.33	1936.94	1461.08
*	28.000	920.00	0.00	0.00	998.40	5900.00	1009.05	0.00	1009.16	9.20	2.68	2380.77	1945.42
*	28.000	920.00	0.00	0.00	998.40	7200.00	1009.40	0.00	1009.53	9.36	2.91	2727.18	2353.14
*	28.000	920.00	0.00	0.00	998.40	8500.00	1009.73	0.00	1009.88	9.47	3.11	3063.02	2762.49
*	28.000	920.00	0.00	0.00	998.40	9700.00	1010.03	0.00	1010.19	9.44	3.27	3381.40	3157.20
	28.000	920.00	0.00	0.00	998.40	22000.00	1012.54	0.00	1012.79	8.16	4.21	7442.14	7702.22
*	29.000	1425.00	0.00	0.00	1000.30	3400.00	1008.87	0.00	1008.94	3.03	2.12	1775.69	1952.09
*	29.000	1425.00	0.00	0.00	1000.30	4300.00	1009.31	0.00	1009.40	3.69	2.44	2064.82	2238.18
*	29.000	1425.00	0.00	0.00	1000.30	5900.00	1009.93	0.00	1010.06	4.66	2.95	2520.48	2733.56
	29.000	1425.00	0.00	0.00	1000.30	7200.00	1010.35	0.00	1010.51	5.36	3.31	2899.98	3110.64
	29.000	1425.00	0.00	0.00	1000.30	8500.00	1010.74	0.00	1010.92	5.97	3.63	3303.59	3479.84
	29.000	1425.00	0.00	0.00	1000.30	9700.00	1011.06	0.00	1011.28	6.43	3.89	3699.91	3823.92
	29.000	1425.00	0.00	0.00	1000.30	22000.00	1013.58	0.00	1013.95	8.78	5.56	8144.60	7426.27
*	30.000	715.00	0.00	0.00	1001.60	3400.00	1009.31	0.00	1009.48	29.09	3.41	1128.78	630.37
*	30.000	715.00	0.00	0.00	1001.60	4300.00	1009.79	0.00	1009.95	20.65	3.36	1561.93	946.22
*	30.000	715.00	0.00	0.00	1001.60	5900.00	1010.45	0.00	1010.62	15.46	3.44	2291.25	1500.40
*	30.000	715.00	0.00	0.00	1001.60	7200.00	1010.90	0.00	1011.08	13.59	3.54	2828.56	1952.87
*	30.000	715.00	0.00	0.00	1001.60	8500.00	1011.32	0.00	1011.50	12.47	3.66	3330.58	2407.16
	30.000	715.00	0.00	0.00	1001.60	9700.00	1011.67	0.00	1011.86	11.62	3.75	3789.75	2845.79
	30.000	715.00	0.00	0.00	1001.60	22000.00	1014.32	0.00	1014.57	8.99	4.56	8684.82	7338.90

	SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
*	31.000	185.00	0.00	0.00	1001.60	3400.00	1009.62	0.00	1009.66	2.98	1.51	2449.53	1971.04
*	31.000	185.00	0.00	0.00	1001.60	4300.00	1010.07	0.00	1010.11	2.93	1.65	2933.88	2512.20
*	31.000	185.00	0.00	0.00	1001.60	5900.00	1010.72	0.00	1010.77	3.00	1.87	3676.65	3408.01
*	31.000	185.00	0.00	0.00	1001.60	7200.00	1011.17	0.00	1011.23	3.08	2.04	4215.16	4099.73
*	31.000	185.00	0.00	0.00	1001.60	8500.00	1011.58	0.00	1011.65	3.16	2.19	4725.62	4783.41
*	31.000	185.00	0.00	0.00	1001.60	9700.00	1011.94	0.00	1012.02	3.22	2.31	5177.20	5408.42
*	31.000	185.00	0.00	0.00	1001.60	22000.00	1014.60	0.00	1014.74	3.61	3.21	10759.14	11581.08

DM 6-DESIGN

SUMMARY PRINTOUT TABLE 150

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
	18.000	3400.00	994.98	0.00	0.00	0.00	150.63	0.00
	18.000	4300.00	996.36	1.38	0.00	0.00	158.87	0.00
	18.000	5900.00	997.47	1.11	0.00	0.00	165.50	0.00
	18.000	7200.00	998.30	.83	0.00	0.00	170.46	0.00
	18.000	8500.00	999.07	.77	0.00	0.00	175.06	0.00
	18.000	9700.00	999.75	.68	0.00	0.00	194.26	0.00
	18.000	22000.00	1004.50	4.75	0.00	0.00	764.17	0.00
	19.000	3400.00	996.40	0.00	1.42	0.00	153.81	505.00
	19.000	4300.00	997.32	.92	.96	0.00	159.28	505.00
	19.000	5900.00	998.44	1.12	.97	0.00	166.01	505.00
	19.000	7200.00	999.27	.83	.97	0.00	170.94	505.00
	19.000	8500.00	1000.03	.76	.96	0.00	175.53	505.00
	19.000	9700.00	1000.69	.66	.94	0.00	179.53	505.00
	19.000	22000.00	1005.61	4.92	1.11	9.21	958.46	505.00
*	19.100	3400.00	996.74	0.00	.34	0.00	109.90	135.00
*	19.100	4300.00	997.60	.86	.28	0.00	109.91	135.00
*	19.100	5900.00	998.67	1.07	.23	0.00	109.93	135.00
*	19.100	7200.00	999.44	.77	.18	0.00	109.94	135.00
	19.100	8500.00	1000.19	.74	.16	0.00	109.95	135.00
	19.100	9700.00	1000.83	.64	.13	0.00	109.96	135.00
	19.100	22000.00	1005.17	4.34	-.44	8.43	970.73	135.00
	19.200	3400.00	996.77	0.00	.03	0.00	109.90	35.00
	19.200	4300.00	997.64	.87	.03	0.00	109.91	35.00
	19.200	5900.00	998.73	1.09	.06	0.00	109.93	35.00
	19.200	7200.00	999.52	.79	.08	0.00	109.94	35.00
	19.200	8500.00	1000.29	.77	.10	0.00	109.95	35.00
	19.200	9700.00	1000.95	.66	.12	0.00	109.96	35.00
*	19.200	22000.00	1006.90	5.95	1.73	10.14	1400.00	35.00
	19.300	3400.00	996.79	0.00	.02	0.00	109.89	40.00
	19.300	4300.00	997.66	.87	.02	0.00	109.90	40.00
	19.300	5900.00	998.76	1.10	.03	0.00	109.92	40.00
	19.300	7200.00	999.56	.80	.04	0.00	109.93	40.00
	19.300	8500.00	1000.33	.77	.04	0.00	109.94	40.00
	19.300	9700.00	1000.99	.67	.04	0.00	109.95	40.00
	19.300	22000.00	1006.52	5.53	-.38	9.74	1188.05	40.00
	19.400	3400.00	996.81	0.00	.03	0.00	109.89	40.00
	19.400	4300.00	997.70	.88	.04	0.00	109.90	40.00
	19.400	5900.00	998.82	1.12	.06	0.00	109.92	40.00
	19.400	7200.00	999.64	.82	.08	0.00	109.93	40.00
	19.400	8500.00	1000.43	.79	.10	0.00	109.94	40.00
	19.400	9700.00	1001.12	.69	.12	0.00	109.95	40.00
	19.400	22000.00	1006.52	5.41	.00	9.71	1186.98	40.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	20.000	3400.00	996.83	0.00	.01	0.00	105.13	135.00
*	20.000	4300.00	997.76	.94	.07	.94	157.18	135.00
*	20.000	5900.00	998.94	1.17	.12	2.11	164.21	135.00
*	20.000	7200.00	999.80	.86	.16	2.97	169.38	135.00
	20.000	8500.00	1000.63	.84	.21	3.80	174.10	135.00
	20.000	9700.00	1001.43	.80	.31	4.60	174.11	135.00
*	20.000	22000.00	1008.97	7.55	2.45	12.15	2075.78	135.00
	21.000	3400.00	997.74	0.00	.91	0.00	106.05	495.00
	21.000	4300.00	998.94	1.19	1.17	1.19	158.21	495.00
	21.000	5900.00	1000.04	1.11	1.11	2.30	164.87	495.00
	21.000	7200.00	1000.86	.82	1.07	3.12	169.77	495.00
	21.000	8500.00	1001.65	.78	1.01	3.90	174.42	495.00
	21.000	9700.00	1002.36	.71	.93	4.62	178.76	495.00
*	21.000	22000.00	1009.03	6.67	.05	11.29	2111.57	495.00
*	21.100	3400.00	998.28	0.00	.54	0.00	152.51	135.00
*	21.100	4300.00	999.40	1.12	.47	1.12	159.22	135.00
*	21.100	5900.00	1000.56	1.16	.52	2.28	166.17	135.00
*	21.100	7200.00	1001.41	.85	.54	3.12	171.25	135.00
*	21.100	8500.00	1002.21	.80	.56	3.92	176.06	135.00
*	21.100	9700.00	1002.94	.73	.57	4.65	193.99	135.00
	21.100	22000.00	1009.09	6.15	.06	10.81	2388.58	135.00
	21.200	3400.00	998.39	0.00	.10	0.00	174.22	65.00
	21.200	4300.00	999.51	1.13	.11	1.13	180.97	65.00
	21.200	5900.00	1000.71	1.19	.14	2.32	188.14	65.00
	21.200	7200.00	1001.58	.87	.17	3.19	193.37	65.00
	21.200	8500.00	1002.40	.82	.19	4.02	198.31	65.00
	21.200	9700.00	1003.14	.74	.21	4.76	200.41	65.00
	21.200	22000.00	1009.11	5.97	.02	10.72	2390.41	65.00
	21.300	3400.00	998.38	0.00	.00	0.00	140.00	25.00
	21.300	4300.00	999.50	1.12	-.01	1.12	140.00	25.00
	21.300	5900.00	1000.68	1.18	-.03	2.30	140.00	25.00
	21.300	7200.00	1001.54	.86	-.04	3.16	140.00	25.00
	21.300	8500.00	1002.35	.81	-.05	3.97	140.00	25.00
	21.300	9700.00	1003.08	.73	-.07	4.69	140.00	25.00
*	21.300	22000.00	1008.85	5.77	-.26	10.47	2579.62	25.00
*	21.400	3400.00	1000.83	0.00	2.45	0.00	140.00	35.00
*	21.400	4300.00	1001.27	.45	1.77	.45	140.00	35.00
*	21.400	5900.00	1001.99	.72	1.31	1.17	140.00	35.00
*	21.400	7200.00	1002.54	.55	1.00	1.71	140.00	35.00
*	21.400	8500.00	1003.04	.50	.69	2.21	140.00	35.00
*	21.400	9700.00	1003.48	.44	.41	2.66	140.00	35.00
*	21.400	22000.00	1008.59	5.10	-.26	7.76	2556.63	35.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	21.500	3400.00	1002.20	0.00	1.37	0.00	347.71	25.00
*	21.500	4300.00	1002.90	.70	1.63	.70	473.28	25.00
*	21.500	5900.00	1004.00	1.10	2.01	1.80	623.96	25.00
*	21.500	7200.00	1004.90	.90	2.36	2.70	670.33	25.00
*	21.500	8500.00	1005.60	.70	2.56	3.40	679.67	25.00
*	21.500	9700.00	1006.30	.70	2.82	4.10	738.78	25.00
*	21.500	22000.00	1010.09	3.79	1.50	7.89	2801.46	25.00
	22.000	3400.00	1002.31	0.00	.11	0.00	400.29	150.00
	22.000	4300.00	1003.05	.74	.15	.74	630.98	150.00
	22.000	5900.00	1004.20	1.15	.20	1.89	860.63	150.00
	22.000	7200.00	1005.12	.92	.22	2.81	893.25	150.00
	22.000	8500.00	1005.84	.72	.24	3.53	902.86	150.00
	22.000	9700.00	1006.55	.71	.25	4.24	1003.04	150.00
	22.000	22000.00	1010.25	3.70	.16	7.94	2833.14	150.00
*	23.000	3400.00	1002.86	0.00	.55	0.00	504.06	1020.00
*	23.000	4300.00	1003.71	.84	.66	.84	875.86	1020.00
*	23.000	5900.00	1004.71	1.00	.51	1.85	957.71	1020.00
*	23.000	7200.00	1005.49	.78	.37	2.63	975.76	1020.00
	23.000	8500.00	1006.15	.66	.31	3.29	981.37	1020.00
	23.000	9700.00	1006.81	.66	.26	3.95	986.96	1020.00
	23.000	22000.00	1010.42	3.61	.17	7.56	2797.78	1020.00
	24.000	3400.00	1004.26	0.00	1.40	0.00	719.29	755.00
	24.000	4300.00	1004.72	.46	1.01	.46	759.72	755.00
	24.000	5900.00	1005.42	.70	.71	1.15	917.99	755.00
	24.000	7200.00	1006.00	.58	.51	1.73	994.92	755.00
	24.000	8500.00	1006.56	.56	.41	2.29	1008.90	755.00
	24.000	9700.00	1007.13	.58	.33	2.87	1023.34	755.00
	24.000	22000.00	1010.60	3.47	.18	6.34	2749.09	755.00
*	25.000	3400.00	1005.16	0.00	.89	-4.65	732.00	910.00
	25.000	4300.00	1005.59	.43	.87	-4.22	844.43	910.00
	25.000	5900.00	1006.21	.63	.80	-3.60	925.45	910.00
	25.000	7200.00	1006.68	.46	.68	-3.13	1063.04	910.00
	25.000	8500.00	1007.14	.46	.59	-2.67	1095.02	910.00
	25.000	9700.00	1007.63	.48	.49	-2.18	1102.13	910.00
	25.000	22000.00	1010.85	3.22	.25	1.04	2699.74	910.00
	26.000	3400.00	1005.56	0.00	.40	0.00	729.69	800.00
	26.000	4300.00	1006.00	.45	.42	.45	955.44	800.00
	26.000	5900.00	1006.63	.63	.42	1.08	1195.26	800.00
	26.000	7200.00	1007.08	.45	.41	1.53	1350.15	800.00
	26.000	8500.00	1007.52	.44	.38	1.97	1411.03	800.00
	26.000	9700.00	1007.97	.44	.34	2.41	1468.33	800.00
	26.000	22000.00	1011.09	3.13	.24	5.54	2820.01	800.00

	SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
*	27.000	3400.00	1006.43	0.00	.88	0.00	724.84	1110.00
*	27.000	4300.00	1006.94	.51	.94	.51	934.66	1110.00
*	27.000	5900.00	1007.56	.62	.93	1.13	1155.11	1110.00
*	27.000	7200.00	1007.99	.43	.91	1.56	1223.99	1110.00
*	27.000	8500.00	1008.39	.40	.87	1.96	1253.28	1110.00
*	27.000	9700.00	1008.77	.38	.80	2.33	1278.99	1110.00
*	27.000	22000.00	1011.69	2.92	.59	5.25	2654.18	1110.00
*	28.000	3400.00	1008.17	0.00	1.73	0.00	820.56	920.00
*	28.000	4300.00	1008.55	.38	1.61	.38	890.24	920.00
*	28.000	5900.00	1009.05	.50	1.49	.88	959.81	920.00
*	28.000	7200.00	1009.40	.35	1.41	1.23	1003.36	920.00
*	28.000	8500.00	1009.73	.33	1.34	1.56	1051.14	920.00
*	28.000	9700.00	1010.03	.30	1.26	1.86	1128.62	920.00
	28.000	22000.00	1012.54	2.51	.85	4.37	2138.78	920.00
*	29.000	3400.00	1008.87	0.00	.70	0.00	594.86	1425.00
*	29.000	4300.00	1009.31	.44	.76	.44	680.32	1425.00
*	29.000	5900.00	1009.93	.62	.88	1.06	812.19	1425.00
	29.000	7200.00	1010.35	.42	.95	1.48	984.58	1425.00
	29.000	8500.00	1010.74	.38	1.01	1.86	1139.65	1425.00
	29.000	9700.00	1011.06	.33	1.04	2.19	1273.68	1425.00
	29.000	22000.00	1013.58	2.51	1.04	4.71	2399.36	1425.00
*	30.000	3400.00	1009.31	0.00	.44	0.00	832.97	715.00
*	30.000	4300.00	1009.79	.48	.47	.48	979.54	715.00
*	30.000	5900.00	1010.45	.66	.52	1.14	1162.33	715.00
*	30.000	7200.00	1010.90	.45	.55	1.60	1209.89	715.00
*	30.000	8500.00	1011.32	.41	.58	2.01	1252.70	715.00
	30.000	9700.00	1011.67	.36	.61	2.36	1290.62	715.00
	30.000	22000.00	1014.32	2.65	.74	5.01	2538.48	715.00
*	31.000	3400.00	1009.62	0.00	.31	0.00	1035.74	185.00
*	31.000	4300.00	1010.07	.45	.28	.45	1111.70	185.00
*	31.000	5900.00	1010.72	.65	.27	1.10	1173.46	185.00
*	31.000	7200.00	1011.17	.45	.27	1.55	1216.27	185.00
*	31.000	8500.00	1011.58	.41	.27	1.96	1255.51	185.00
*	31.000	9700.00	1011.94	.35	.27	2.32	1289.22	185.00
*	31.000	22000.00	1014.60	2.66	.28	4.98	2876.42	185.00

APPENDIX B

INTERIOR FLOOD CONTROL

APPENDIX B

INTERIOR FLOOD CONTROL

TABLE OF CONTENTS

PARAGRAPH	DESCRIPTION	PAGE
1	INTRODUCTION	B-1
2-4	GENERAL	B-1
5-7	CHANGES TO THE GDM	B-1
	INTERIOR FLOOD CONTROL FEATURES - LEVEED AREA	B-4
8-10	WATERSHEDS AND EXISTING DRAINAGE PATTERNS	B-4
11-12	DRAINAGE PATTERNS WITH PROPOSED CONDITIONS	B-4
13	PONDING AREAS	B-4
14	DEGREE OF PROTECTION	B-4
15	STREAM FLOW DATA	B-5
16	HISTORICAL RAINFALL DATA	B-5
17-18	THEORETICAL RAINFALL DATA	B-5
19	UNIT HYDROGRAPHS	B-5
20-21	RUNOFF HYDROGRAPHS	B-7
22	SEEPAGE	B-7
23-28	SWALE DESIGN FOR MHS AND RCA	B-9
29-33	OUTLET FOR CENTRAL AREA	B-11
34	SIDE CHANNEL INLET DESIGN	B-14
35-36	MAYO RUN, STATION 19+45R	B-14
37-39	SLATTERLY PARK INLET, STATION 44+75R	B-15
40-46	NORTH AREA INLETS, STATIONS 64+40L & 65+80L	B-16
47-52	SIDE CHANNEL INLET OVERFLOW EMBANKMENTS	B-17
53-58	STORM SEWER OUTLET DESIGN	B-19
	REFERENCES	B-21

TABLES

NUMBER	TITLE	
B-1	Changes to the GDM - Interior Flood Control Features - Leveed Area	B-2
B-2	Changes to the GDM - Storm Sewer Outlets	B-2
B-3	Changes to the GDM - Side Channel Inlets	B-3
B-4	16-Hr Rainfall Distributions	B-6
B-5	Watershed Lag Times	B-7
B-6	Watershed Unit Hydrographs	B-8
B-7	Watershed Parameters	B-8
B-8	Watershed Runoff Hydrographs	B-9
B-9	Swale Designs	B-9
B-10	Swale Scour Protection	B-10
B-11	Swale Embankment Crest Designs	B-11
B-12	Swale Embankment Slope Design	B-11
B-13	1-Percent Chance Storm Routing - Central Outlet	B-12
B-14	Central Area Outlet - Preformed Scour Hole Design	B-13
B-15	Side Channel Inlets - Lag Time Design Parameters	B-14
B-16	Side Channel Inlets - Peak Discharge Design Parameters	B-14
B-17	Mayo Run - Culvert Extensions	B-15
B-18	Bituminous Path Crossing - Slatterly Park Side Channel Inlet	B-15
B-19	Preformed Scour Hole Design - Storm Sewer Outlet for North Areas #1 and #2	B-16
B-20	Side Channel Inlet Embankments - Crest Designs	B-18
B-21	Side Channel Inlet Embankments - Slope Designs	B-18
B-22	Type 1 Storm Sewer Outlets - Drop Manholes	B-19
B-23	Type 2 Storm Sewer Outlets - Concrete Headwalls	B-20
B-24	Type 3 Storm Sewer Outlets - Standard End Sections	B-20
B-25	Type 4 Storm Sewer Outlets - Drop Inlets	B-20

PLATES

NUMBER	TITLE
B-1	INTERIOR FLOOD CONTROL - LEVEED AREA
B-2	INTERIOR FLOOD CONTROL, CONTRIBUTING WATERSHEDS, BEAR CREEK
B-3	POINT RAINFALL DEPTHS, ROCHESTER, MINNESOTA
B-4	100-YEAR FLOOD, BEAR CREEK AT HIGHWAY 14 & 52
B-5	INTERIOR FLOOD CONTROL, SIDE CHANNEL INLET, MAYO RUN

APPENDIX B
INTERIOR FLOOD CONTROL

INTRODUCTION

1. This appendix presents the design of the interior flood control features for the following:

   a. Interior flood control for the area west of the left bank tie-back levee near the upstream drop structure.
   b. Existing storm sewer outlets entering the modified channel.
   c. Side channel inlets entering the modified channel.

All elevations presented in this appendix are referenced to National Geodetic Vertical Datum (NGVD) of 1929, all discharges and runoff values are in cubic feet per second (cfs), and all velocities are in feet per second (fps).

GENERAL

2. Construction of the left bank tie-back levee requires interior flood control features for the Mayo High School area, located between channel station 68+00L and levee station 18+50L, and the area near the Resurrection Catholic Church located south of the high school between levee stations 18+50L and 28+80L. Runoff from the high school area will be directed to the main channel, downstream of the levee, by an intercepting swale paralleling the levee. The church area runoff will be conveyed in the same manner; however, the runoff will enter a side channel inlet where flow enters the main channel through a 48-inch culvert with flap gate. The location of these features are shown on Plate B-1.

3. There are four existing side channel inlets downstream of the leveed area. Flow from three of these inlets will be conveyed to the lower channel invert by an overflow embankment constructed of riprap. The fourth is protected by existing bedrock.

4. Sixteen existing storm sewer outlets, located along the project length, will be modified. Thirteen are modified due to the lowering and widening of the channel and three are modified due to bridge modifications. Modifications to the outlets include the use of drop manholes, concrete headwalls, standard end sections, and drop inlets. Existing rock, riprap, or concrete is used for scour protection.

CHANGES TO THE GDM

5. The upstream drop structure, overflow embankment, and tie-back levees were redesigned. The current design is discussed in detail in the HYDRAULIC STRUCTURE DESIGN section of Appendix A. The significantly reduced length of the left bank tie-back levee resulted in major changes to the interior flood control features shown in the GDM. Table B-1 gives a brief summary of these changes.

6. There are four existing side channel inlets downstream of the upstream drop structure. Design changes were made due to the redesign of the interior flood control of the leveed area, addition of concrete and bituminous paths, and economics. Changes from the GDM are presented in Table B-2.

7. Changes were also made to storm sewer outlet designs. These changes are due to the relocation of the downstream drop structure, addition of bike paths, channel realignment, and economics. The channel realignment caused minor changes to pipe lengths. Table B-3 shows the major changes from the GDM.

TABLE B-1
Changes to the GDM
Interior Flood Control Features - Leveed Area

Location	GDM Design Feature	Present Design
Downstream Mayo High School	Intercepting swale enters main channel via a drop manhole and 54" RCP outlet with flap gate	Intercepting swale enters main channel via side channel inlet
16th St SE	Intercepting swales enter existing side channel via drop inlet to 60" RCP storm sewer extension	Intercepting swale enters existing side channel via side channel inlet
16th St SE	Flow ponds at tie-back levee	No ponding area necessary
16th St SE	Flows enter main channel via 60" RCP and gatewell with sluice gate & flap gate	Flows enter main channel via 48" RCP with trash rack & flap gate
16 1/2 St SE	Flow will pond and enter main channel via twin 72" RCP and gatewell with sluice gate & flap gate	Existing conditions (this area is outside the flood control area)

TABLE B-2
Changes to the GDM - Side Channel Inlets

Approx. Station	GDM Design	Present Design
19+45R	Riprap existing side slopes	Shape side slopes to tie in with main channel side slopes
		Extend existing RCP oval pipes at 9th Ave SE 83' and 91' from bridge outlet for bituminous path crossing
44+75R	Existing conditions meet modified channel	Flow enters main channel via riprap overflow embankment to riprap high flow bench to interlocking concrete slope protection of low flow channel
		Bituminous path crosses 3-18" RCP with standard end sections
64+40L	Side Channel flow is directed to inlet of 54" RCP with flap gate	Side channel flow enters main channel via riprap overflow embankment to channel invert
65+80L	Side channel flow is intercepted at existing 48" RCP and enters main channel via manhole with 54" RCP outlet with flap gate	Side channel flow enters main channel via riprap overflow embankment to channel invert

TABLE B-3
Changes to the GDM
Storm Sewer Outlets

Station	GDM Design	Present Design	Reason for Change
6+07R	existing 15" RCP outlet on side slope	existing 15" RCP with drop manhole and 18" RCP outlet	convey flow beneath concrete pathway
13+90R	existing 15" VCP outlet through wing wall of drop structure	existing 15" VCP with drop manhole and 18" RCP outlet	relocation of drop structure
14+20L	existing 24" RCP outlet through wing wall of drop structure	existing 24" RCP outlet with concrete headwall and basin	relocation of drop structure
23+70L	existing 12" RCP through 6th St SE wingwall	existing 12" RCP with drop manhole and 18" RCP outlet through 6th St SE wingwall	existing wingwall removed
23+80R	existing 15" RCP through 6th St SE bridge abutment	existing 15" RCP with drop manhole and 18" RCP outlet to catch basin at station 24+80R	insufficient clearance beneath concrete pathway
24+80R	not presented	catch basin with 18" RCP outlet through retaining wall	interior flood control behind retaining wall
27+15L	existing 12" RCP with drop manhole and 18" RCP outlet	existing 12" RCP with standard end section	more economical
27+65R	existing 12" CMP with drop manhole and 18" RCP outlet	existing 12" CMP with standard end section	more economical
30+40L	existing 15" CMP with drop manhole and 18" RCP outlet	existing 15" CMP with standard end section	more economical
31+05R	existing 18" RCP with drop manhole and 18" RCP outlet	existing 18" RCP with concrete head-wall and basin	more economical
61+33R	not presented	drop manhole with beehive inlet and 18" RCP outlet	convey flow beneath concrete pathway
62+22R&L	Drop inlet with 24" RCP outlet through Highway 14 bridge abutment	drop manhole with beehive inlet and 18" RCP outlet through Highway 14 bridge abutment	more economical

INTERIOR FLOOD CONTROL FEATURES - LEVEED AREA

WATERSHEDS AND EXISTING DRAINAGE PATTERNS

8. The watershed contributing runoff to the area west of the proposed left bank tie-back levee covers about 100 acres. It is boarded by 16 1/4 St SE, 16 1/2 St SE, and the proposed levee to the south, high ground north of 16th St SE and through the Mayo High School grounds on the north and by the railroad tracks south of 16th St SE on the east. The watershed has been divided into two sub-watersheds referred to as the Mayo High School grounds (MHS) and the Central Area (CA). The Central Area is further divided into 2 sub-areas. They are referred to as Central Area 1 (CA-1) and Resurrection Catholic Church Area (RCA). The size and location of these watershed areas and sub-areas are shown on Plate B-2. The Central Area watershed is generally developed with residential property except for small areas near the proposed levee and the Mayo High School grounds.

9. Runoff from the Central Area under existing conditions drains mostly from west to east with the aid of a storm sewer system along 16th Street S.E. The sewer system, comprised of about 3,000 feet of RCP varying in size from 18-inches to 48-inches in diameter, discharges into an outlet channel that angles eastward to its confluence with Bear Creek for a distance of about 800 feet. At the sewer outlet, the channel bottom is about 5 feet wide with 1V:1H side slopes and has a depth of about 8 feet. Grass and an occasional clump of willows line the channel bottom. Side slopes and overbanks are also well grassed. At about 200 feet downstream from the 48-inch culvert, the channel bottom widens to about 10 to 12 feet. The small part of the Central Area east of 11th Avenue S.E. drains overland from south to north into the 16th Street outlet channel.

10. The portion of the Mayo High School Grounds which will be affected by the proposed levee currently drains overland from west to east, eventually flowing directly into Bear Creek.

DRAINAGE PATTERNS WITH PROPOSED CONDITIONS

11. With the proposed flood control plan, runoff from the Central Area reaches the existing side channel inlet located at levee station 18+50L. either through the existing storm sewer system and/or by overland flow. Overland flow is directed to the side channel by a swale paralleling the levee and enters via a riprap protected overflow embankment that slopes to the side channel invert. The remainder of the flow enters the side channel through an existing 48-inch RCP storm sewer. The water flows into the main channel through a 48-inch RCP, with flap gate, that penetrates the tie-back levee. The Mayo High School swale extends to the north edge of the side channel and carries excess flows from the Central Area if necessary.

12. Runoff from the Mayo High School grounds is directed to the main channel by a swale paralleling the tie-back levee. Flow enters the main channel via a riprap protected overflow embankment that slopes to the proposed channel invert.

PONDING AREAS

13. Backwater will occur at the Central Area inlet, as sufficient hydraulic head is produced to move water through the culvert. A ponding area, however, is not required to store water.

DEGREE OF PROTECTION

14. The degree of protection for the design of the interior flood control features is the 1-percent chance exceedance event.

STREAM FLOW DATA

15. A USGS crest-stage gage was placed at the downstream side of the west bound US Highway 14 bridge in July 1968; however, no stream flow records are available on Bear Creek. The flood hydrographs for Bear Creek, and the interior watersheds, were determined using synthetic hydrograph methods and theoretical rainfall data. A stage discharge rating curve for Bear Creek at the confluence with South Fork Zumbro River was developed from theoretical water surface profiles based on both existing and modified conditions.

HISTORICAL RAINFALL DATA

16. Rainfall records and isohyetal data for the storm of 5-6 July, 1978, which resulted in record flood levels on Bear Creek and four deaths, were obtained from the National Weather Service, which maintains a recording rain gage at Rochester Municipal Airport. A basin weighted average rainfall was then distributed according to the pattern recorded at the airport gage.

THEORETICAL RAINFALL DATA

17. The 1/4-, 1/2-, 1-, 2-, 3-, 6-, 12-, 24-, and 96-hour duration rainfall depths for the 2-, 5-, 10-, 25-, 50-, and 100-year theoretical rainfall events in the Rochester, MN area were developed from National Weather Service (U.S. Weather Bureau) publication TP-40 and HYDRO-35. A point rainfall depth versus duration plot of the storms mentioned above is shown on Plate B-3. The critical rainfall duration was determined to be 16 hours. That is, longer storm durations did not produce higher discharges.

18. It is assumed that the rainfall pattern for the interior watershed runoff is the same 16-hour pattern used for streamflow runoff. The 16-hour rainfall for the 100-year theoretical event was obtained from the depth versus duration plot and applied to the rainfall pattern. These distributions are shown in Table B-4.

UNIT HYDROGRAPHS

19. Unit hydrographs were developed for the Mayo High School grounds (MHS), the Central Area (CA), and a sub-area of CA near Resurrection Catholic Church (RCA). The unit hydrographs for the interior watersheds were developed using the Soil Conservation Service (SCS) unit hydrograph method used in the HEC-1 computer program. Lag times were computed using the empirical relationship (reference f):

$$T_L = 0.6\ T_c$$

where,

T_L = Lag Time; weighted time of concentration
T_c = Time of concentration; time for runoff to travel from hydraulically most distant point of the watershed to a point of interest.

Time of concentration is the sum of travel time (T_t) values for the various consecutive flow segments. Travel time was determined by;

$$T_t = \frac{L}{3600\ V}$$

where, L = flow length (ft)
V = average overland flow velocity (fps)

TABLE B-4
16-Hour Rainfall Distributions

Distribution Hour	Distribution Minute	Theoretical 100-Yr Storm	Distribution Hour	Distribution Minute	Theoretical 100-Yr Storm
0	10	0	8	10	0.02
0	20	0	8	20	0.03
0	30	0	8	30	0.01
0	40	0.02	8	40	0.03
0	50	0.03	8	50	0.06
1	0	0.01	9	0	0.02
1	10	0.02	9	10	0.03
1	20	0.03	9	20	0.06
1	30	0.01	9	30	0.02
1	40	0.02	9	40	0.02
1	50	0.03	9	50	0.03
2	0	0.01	10	0	0.01
2	10	0.02	10	10	0.03
2	20	0.03	10	20	0.06
2	30	0.01	10	30	0.02
2	40	0.02	10	40	0.04
2	50	0.03	10	50	0.09
3	0	0.01	11	0	0.04
3	10	0.03	11	10	0.04
3	20	0.06	11	20	0.09
3	30	0.02	11	30	0.04
3	40	0.02	11	40	0.04
3	50	0.03	11	50	0.09
4	0	0.01	12	0	0.04
4	10	0.02	12	10	0.07
4	20	0.03	12	20	0.15
4	30	0.01	12	30	0.06
4	40	0.02	12	40	0.16
4	50	0.03	12	50	0.33
5	0	0.01	13	0	0.13
5	10	0.02	13	10	0.62
5	20	0.03	13	20	1.27
5	30	0.01	13	30	0.50
5	40	0.02	13	40	0.07
5	50	0.03	13	50	0.15
6	0	0.01	14	0	0.06
6	10	0	14	10	0.02
6	20	0	14	20	0.03
6	30	0	14	30	0.01
6	40	0.02	14	40	0.03
6	50	0.03	14	50	0.06
7	0	0.01	15	0	0.02
7	10	0.02	15	10	0.04
7	20	0.03	15	20	0.09
7	30	0.01	15	30	0.04
7	40	0.02	15	40	0.02
7	50	0.03	15	50	0.03
8	0	0.01	16	0	0.01

Shallow concentrated flow conditions were assumed and average overland flow velocity was determined by,

$$V = 16.1345\ (s)^{0.5}$$

from TR-55, Appendix F;

where,

s = watercourse slope (ft/ft).

Resulting lag time valves for the two watersheds, including subareas, are shown in Table B-5. Slopes and areas were determined from 1 foot and 2 foot contour interval maps for the MHS and CA areas respectively.

TABLE B-5
Watershed Lag Times

Watershed	Average Velocity	Length (ft)	Percent Slope	T_t (hrs)	T_c (hrs)	T_L Lag Time (hrs)
MHS	0.98	1900	.37	.54	.54	.32
CA-1	1.08	3000	.45	.78	.78	.47
RCA	1.47	800	.83	.16	.16	.10
CA		3800			.94	.56

Unit hydrographs were developed for time intervals of 5 minutes. A time interval less than or equal to one half the Lag Time (T_L) was considered to be short enough so as not to miss the peak of the unit hydrograph. Resulting watershed unit hydrographs are shown in Table B-6.

RUNOFF HYDROGRAPHS

20. Runoff hydrographs for each of the interior watersheds were generated using the SCS method in the HEC-1 computer program. The SCS curve numbers were selected from Table 2-2 of TR-55 (reference f) for the average antecedent runoff condition (ARC). Table B-7 shows the parameters used to determine runoff hydrographs.

21. Hydrographs were generated for 5 minute intervals and the resulting runoff hydrographs were condensed to 1/2 intervals and are presented in Table B-8.

SEEPAGE

22. Seepage along the left bank tie-back levee is insignificant in comparison to runoff flow rates. Seepage values are presented in Appendix C.

TABLE B-6
Watershed Unit Hydrographs

Time Hr.	Min.	Mayo High School Grounds	Central Area	Resurrection Church Area
00	00	0	0	0
00	05	6	5	28
00	10	21	15	42
00	15	41	30	18
00	20	50	51	7
00	25	49	72	3
00	30	40	84	1
00	35	28	88	0
00	40	19	87	
00	45	13	79	
00	50	9	70	
00	55	6	58	
01	00	4	44	
01	05	3	34	
01	10	2	27	
01	15	1	22	
01	20	1	18	
01	25	1	14	
01	30	0	11	
01	35		9	
01	40		7	
01	45		6	
01	50		5	
01	55		4	
02	00		3	
02	05		2	
02	10		2	
02	15		1	
02	20		1	
02	25		1	
02	30		1	
02	35		1	
02	40		1	
02	45		0	

TABLE B-7
Watershed Parameters

Watershed	Area Sq.M.	Area Acres	SCS Curve Number	T_L Lag Time hours
MHS	0.038	24.2	88	.24
CA	0.110	70.5	80	.56
RCA	0.013	8.3	80	.10

TABLE B-8
Watershed Runoff Hydrographs

Time Hrs	MHS	CA	RCA
.5	0	0	0
1.0	0	0	0
1.5	0	0	0
2.0	0	0	0
2.5	0	0	0
3.0	0	0	0
3.5	0	0	1
4.0	0	0	1
4.5	1	0	0
5.0	1	0	0
5.5	1	0	0
6.0	1	0	0
6.5	1	0	0
7.0	1	0	0
7.5	1	0	0
8.0	2	0	1
8.5	2	1	1
9.0	4	3	1
9.5	4	4	1
10.0	4	4	1
10.5	4	3	2
11.0	6	7	2
11.5	7	11	3
12.0	8	12	3
12.5	11	17	5
13.0	26	38	11
13.5	97	143	46
14.0	92	180	12
14.5	25	126	2
15.0	6	46	2
15.5	8	22	3
16.0	8	21	1
16.5	3	15	0
17.0	0	6	
17.5		1	
18.0		0	

SWALE DESIGN FOR MHS AND RCA

23. The swales are designed to carry the 100-year peak discharge within banks. A bottom width of 10 feet was selected for ease of construction and side slopes of 1V:3H for maintenance purposes. The slope of the swales were selected to conform with existing topography along the left bank tie-back levee and to maintain non-erodible velocities (about 3-fps) within the swales. The swales were modeled using the computer program HEC-2 with discharges decreased proportionately upstream. An overflow embankment is constructed at each of the swale outlets to convey flow into the main channel and side channel inlet for the MHS and RCA areas respectively. The overflow embankment design for each outlet is presented later in this section. Table B-9 shows the design features of the swales. The MHS outlet requires a transition between the outlet embankment and swale approach. The transition fares at a rate of 1-horizontal to 6-longitudinal.

TABLE B-9
Swale Designs

Swale Location	Peak Discharge	Invert Elev. at Embankment	Swale Slope ft/ft	Channel Width at Embankment feet	Swale Bottom Width feet	Transition Length feet
MSH	97	999.5	.0026	20	10	30
RCA	42	1004.5	.0026	10	10	0

24. Depths of the swales vary with the topography along the left bank tie-back levee. The MHS swale has a maximum depth of 3 feet near the mid-point, with depths of 1.5 feet and 0.5 feet at the embankment and the upstream end respectively. The RCA swale has depths of about 2 feet along most of the channel, tapering to zero at the end. The upstream end of the MHS swale extends

through the ridge located on the north side of the Central Area side channel inlet to carry excess discharges from the CA when necessary. This is discussed in detail in the OUTLET FOR CENTRAL AREA portion of this section.

25. Riprap is provided where velocities exceed 3-fps near the swale outlets. Table B-10 shows the channel velocities and the riprap type provided. Type A (12-inch) riprap is adequate for scour protection; however, Type B (18-inch) is required due to possible vandalism.

TABLE B-10
Swale Scour Protection

Location	Average Velocity	Type Protection
MHS Swale		
At Embankment	3.4	
to		18" Type B
End of Transition	2.9	
to		Grass
End of Swale	1.5	
RCA Swale		
At Embankment	3.7	
to		18" Type B
25 ft Upstream	2.9	
to		Grass
End of Swale	1.0	

26. The overflow embankments at the swale outlets are designed in accordance with TR 2-650 (reference i). Model tests showed no stone failure for unit discharges of 5-cfs per foot. The following model tested stone gradation (Type A1) meets the stability requirements for prototype conditions.

Stable Stone Gradation

d_{100}	W_{100}	W_{50}	W_{15}
24"	690	190	28

Therefore, a standard gradation of 27-inch Type F riprap was selected for construction of the embankments.

Type F Riprap Gradation

	Percent lighter by weight (lbs)					
	100		50		15	
d_{100}	Max	Min	Max	Min	Max	Min
27"	984	394	292	197	146	62

Note: Bedding requirement is shown in Table A-17 of Appendix A.

27. Where the swale outlet meets the overflow embankment, the swale invert is the same as the embankment crest elevation The tailwater to embankment crest height determines the maximum stable unit ischarge. This was obtained from Plate 48, Limits of Stability for Nonaccess Type Embankments, of TR 2-650. Since there are no data points for a unit discharge of 5-cfs per foot for the nonaccess

A1 curve, the access type embankment curve was superimposed on to the nonaccess curve to obtain tailwater to crest height limits. As a minimum, the embankment crest lengths are greater than or equal to the swale bottom width (10 feet). The overflow embankments have side slopes of 1V:3H; however, for design purposes, unit discharges are based on a rectangular section and thereby assures a conservative crest length. Table B-11 shows the crest design for the overflow embankments.

TABLE B-11
Swale Embankment Crest Designs

Embankment Location	Peak Discharge	Crest Elevation	Crest Length (feet)	Design Unit q (cfs/ft)	Crest Width (feet)	Maximum Unit q (cfs/ft) Plate 48
MSH	97	999.5	20	4.9	20	5.0
RCA	42	1004.5	10	4.2	20	30.0

28. The downstream embankment face slopes downward at a rate of 1V:4H from its crest elevation to the intercepting channel invert elevation. The MHS embankment enters the modified main channel; whereas, the RCA embankment enters the existing CA side channel inlet. The MHS embankment slopes through the high flow bench of the modified channel and is adjusted landward to provide a minimum depth of 2 feet at the intersection of the embankment slope and the landward edge of the high flow bench. This assures that the design event discharge is well within banks and prevents sour of the high flow bench. Table B-12 shows the design parameters of the embankment slopes. Tailwater to crest heights were determined from the 1-percent chance storm elevations occurring on Bear Creek and the side channel inlet at the time of peak discharge at the swale embankment (see Table B-13).

TABLE B-12
Swale Embankment Slope Design

Embankment Location	Crest Elevation	Slope	Channel Invert Elevation	Crest Height feet	Tail-water Elevation	Estimated Tailwater to Crest (ft)
MHS	999.5	1V:4H	990.7	8.8	993.8	-5.7
RCA	1004.5	1V:4H	998.4	6.1	1006.5	2.0

OUTLET FOR CENTRAL AREA

29. It is assumed that the interior watershed run-off and the streamflow run-off area are dependent upon each other, and that the storms occur simultaneously over both watersheds. This assumption is considered to be valid due to the small size of the Bear Creek watershed, which would increase the likelihood of a rainfall event encompassing the leveed areas and the creek's watersheds. Based upon this assumption, the design of interior flood control features considered the study of gravity flow and blocked gravity flow conditions simultaneously. That is, the effect of high levels on Bear Creek were considered when determining outlet capacity.

30. Watershed runoff hydrographs for the 1-percent chance exceedance were developed for the Central Area (CA) at the proposed inlet point and for Bear Creek at US Highway 14. The results of each are shown on Table B-8 and Plate B-4 respectively.

31. As discussed in paragraph 11, Central Area runoff enters the main channel through a 48-inch RCP that penetrates the tie-back levee. The pipe has a slope of 0.005 feet/foot, an upstream invert elevation of 998.4 feet NGVD, and a length of about 50 feet. A flap gate on the outlet prevents high stages on Bear Creek from flowing back through the pipe (reference b). The pipe entrance has a standard end section with a trash rack to prevent the flap gate from becoming wedged open by debris. Storm routing of the Central Area into Bear Creek is shown in Table B-13. The MHS swale extends through the ridge located on the north side of the side channel inlet and has a depth of about 0.5 feet. Discharges from the CA enter this swale when interior stages exceed an elevation of 1006.8 feet NGVD. This also provides an outlet for Bear Creek backwater should the flap gate fail to close.

TABLE B-13
1-Percent Chance Storm Routing
Central Outlet

Time Hours	Bear Creek Discharge	Bear Creek Elevation	Central Area Inflow	Discharge Through 48"-RCP	Interior Water Elevation	Outflow to MHS Swale
0.0	22	995.8	0	0	998.4	
0.5	22	995.8	0	0	998.4	
1.0	22	995.8	0	0	998.5	
1.5	22	995.8	0	0	998.5	
2.0	22	995.8	0	0	998.5	
2.5	22	995.8	0	0	998.5	
3.0	22	995.8	0	0	998.5	
3.5	22	995.8	0	0	998.5	
4.0	22	995.8	0	0	998.5	
4.5	22	995.8	0	0	998.5	
5.0	22	995.8	0	0	998.5	
5.5	22	995.8	0	0	998.5	
6.0	22	995.8	0	0	998.5	
6.5	22	995.8	0	0	998.5	
7.0	22	995.8	0	0	998.5	
7.5	22	995.8	0	0	998.5	
8.0	22	995.8	0	0	998.5	
8.5	22	995.8	1	1	998.5	
9.0	22	995.8	3	3	998.5	
9.5	22	995.8	4	4	998.6	
10.0	22	995.8	4	4	998.6	
10.5	22	995.8	3	3	998.6	
11.0	22	995.8	7	7	998.6	
11.5	22	995.8	11	11	998.7	
12.0	22	995.8	12	12	998.8	
12.5	25	996.0	17	17	999.1	
13.0	50	996.7	38	38	1000.9	
13.5	300	999.4	143	143	1004.6	
14.0	800	1000.9	180	180	1006.5	
14.5	2000	1003.5	126	126	1006.3	
15.0	3200	1005.0	46	46	1005.5	
15.5	4500	1005.7	22	22	1005.9	
16.0	5900	1006.2	21	21	1006.4	

TABLE B-13 (cont.)
1-Percent Chance Storm Routing
Central Outlet

Time Hours	Bear Creek Discharge	Bear Creek Elevation	Central Area Inflow	Discharge Through 48"-RCP	Interior Water Elevation	Outflow to MHS Swale
16.5	6800	1006.5	15	15	1006.7	0
17.0	7700	1006.8	6	5	1006.9	1
17.5	8100	1007.0	1	0	1007.0	1
18.0	8500	1007.1	0	0	1006.8	0
18.5	8250	1007.0	0	0	1006.8	
19.0	8000	1006.9	0	0	1006.8	
19.5	7700	1006.8	0	0	1006.8	
20.0	7300	1006.7	0	0	1006.8	
20.5	7050	1006.6	0	2	1006.8	
21.0	6800	1006.5	0	2	1006.7	
21.5	6500	1006.4	0	2	1006.6	
22.0	6200	1006.3	0	2	1006.5	
22.5	5800	1006.2	0	2	1006.4	
23.0	5300	1006.0	0	4	1006.2	
23.5	4800	1005.8	0	3	1006.0	
24.0	4300	1005.6	0	3	1005.8	
24.5	3900	1005.4	0	2	1005.6	
25.0	3500	1005.2	0	2	1005.4	
25.5	3050	1004.8	0	2	1005.0	
26.0	2600	1004.4	0	2	1004.6	
26.5	2350	1004.1	0	1	1004.3	

32. A preformed scour hole at the exit portal of the 48-inch RCP dissipates the outflow energy and prevents downstream erosion. The scour hole is designed in accordance with HDC Charts 722-6 and 722-7 (reference i) for a tailwater depth of 2.5 feet peak discharge. Table B-14 shows the scour hole dimensions and riprap design.

TABLE B-14
Central Area Outlet - Preformed Scour Hole Design

Discharge	D_0 Diameter Discharge Pipe (ft)	1/2 D_0 Depth Scour Hole (ft)	2 D_0 Basin Width (ft)	3 D_0 Basin Length (ft)	Side Slopes	Riprap Size D_{50} (ft)	Riprap Weight W_{50} (lbs)
180	4	2	8	12	1V:3H	0.86	52

33. Based on the W_{50} minimum riprap requirement, the scour hole is protected by a blanket of 18-inch Type B riprap. The same riprap gradation is also provided around the flared inlet for erosion protection.

Type B Riprap Gradation

	Percent lighter by weight (lbs)					
	100		50		15	
d_{100}	Max	Min	Max	Min	Max	Min
18"	292	117	86	58	48	18

Note: Bedding requirement is shown in Table A-17 of Appendix A.

SIDE CHANNEL INLET DESIGN

34. There are five side channel inlets along the project length. The design of the side channel inlet for the Central Area (CA), levee station 18+50L, is presented as part of the OUTLET FOR CENTRAL AREA portion of the INTERIOR FLOOD CONTROL FEATURES - LEVEED AREA section of this Appendix. The design of the remaining four are presented here beginning at the downstream end of the project. Locations of each inlet are shown in Table B-3. Peak discharges for the 1-percent chance exceedance were developed for each inlet drainage area using the SCS method of the HEC-1 computer program. This methodology is presented in the UNIT HYDROGRAPH and RUNOFF HYDROGRAPHS portions of the INTERIOR FLOOD CONTROL FEATURES - LEVEED AREA section. Table B-15 and B-16 show the watersheds contributing runoff to the side channel inlets and the design parameters used to determine lag times and peak discharges. The locations of the North Area (NA) and Mayo Run watersheds are shown on Plates B-2 and B-5 respectively. The descriptions of the watersheds are given later in this section.

TABLE B-15
Side Channel Inlets
Lag Time Design Parameters

Watershed	Inlet Station Location	Average Velocity	Length (feet)	Percent Slope	T_c (hrs)	T_L Lag Time (hrs)
Mayo Run	19+45R	1.55	12,500	0.92	5.5	3.3
Slatterly Park	44+75R	1.70	700	1.08	0.33	0.20
North Area #1	64+40L	1.14	1,500	0.50	0.47	0.28
North Area #2	66+40L	1.07	3,100	0.44	0.92	0.55
North Area #3	65+80L	1.03	2,400	0.41	0.69	0.41

TABLE B-16
Side Channel Inlets
Peak Discharge Design Parameters

Watershed	Inlet Station Location	Drainage Areas Sq. Mi.	Drainage Areas Acres	SCS Curve Number	Peak Discharge
Mayo Run	19+45R	1.17	749	74	446
Slatterly Park	44+75R	0.016	10.2	74	36
North Area #1	64+40L	0.033	21.3	87	86
North Area #2	65+80L	0.099	63.4	86	180
North Area #3	65+80L	0.071	45.4	86	155

Note: The side channel inlet located at station 65+80L receives runoff from North Areas 2 and 3. The peak discharges occur at the same time; therefore, the total peak discharge is 335 cfs.

MAYO RUN, STATION 19+45R

35. The Bear Creek modified channel bottom, as well as the existing channel bottom of Mayo Run, is exposed bedrock at this location. Therefore, scour protection of the channel bottom is not necessary and the 1V:2.5H side slope of the modified main channel simply slopes upward to meet the Mayo Run existing channel invert. The existing side slopes of Mayo Run near the outlet are reshaped to match the modified main channel side slopes of 1V:2.5H and 1V:3H. The side slopes are riprap protected in the same manner as the main channel.

36. A bituminous path crosses Mayo Run near the outlet. This crossing is accomplished by extending the two existing 82 feet long, 4.5 foot by 5 foot oval culverts that pass beneath 9th Ave SE. The extensions are 83 feet and 91 feet long. The culverts will pass the 1-percent chance storm discharge under the available head upstream of the culverts. Should stages upstream of the culverts exceed the crown elevation of 9th Ave SE, weir flow across a portion of the street will occur and the flow will re-enter the channel downstream of the culvert extensions. The culvert extensions lie on the existing exposed bedrock channel bottom with a slope consistent with the existing culverts. Table B-17 shows the proposed culvert conditions.

TABLE B-17
Mayo Run - Culvert Extensions

Pipe No.	Existing Upstream Elevation	Extension Downstream Elevation	Percent Culvert Slope	Total Length (feet)	Available Head (feet)	Discharge Capacity
1	987.1	984.4	1.66	165	7.0	240
2	987.0	984.4	1.63	173	7.0	240

Note: Discharge capacity is based on RCP 60-inch elliptical pipe (reference h).

SLATTERLY PARK INLET, STATION 44+75R

37. This small existing swale drains a small area of the Slatterly Park watershed (SP) and enters the modified main channel on the right bank at station 44+75R. Flow enters the main channel via an overflow embankment designed in accordance with TR 2-650 (reference i). The embankment conveys the flow from the point of interception by the modified main channel to the high flow bench where a riprap protected channel across the high flow bench conveys flows to the interlocking concrete slope protection of the low flow channel. The design of this embankment and the two North Area side channel inlet embankments are presented in the SIDE CHANNEL INLET OVERFLOW EMBANKMENTS portion of this section.

38. A bituminous path crosses the swale upstream of its outlet to the modified main channel. Table B-18 shows the culvert design for the 1-percent chance storm peak discharge.

TABLE B-18
Bituminous Path Crossing
Slatterly Park Side Channel Inlet

Peak Discharge	Available Head (feet)	RCP Pipe Dia. (inches)	Approx. Length (feet)	Percent Pipe Slope	Pipe Capacity	No. of Pipes Required
36	2.5	18	25	0.444	12	3

Note: Pipe slope is designed for a flow velocity of 3-fps flowing 1/4 full (reference c and h).

39. The channel bottom width at the crossing is 11 feet to accommodate standard end sections for each pipe. The overflow embankment crest length is 7 feet (see Table B-20); therefore, a transition flaring at a rate of 1-horizontal to 6-longitudinal is provided. This results in a transition length of 12 feet and comprises the embankment crest width.

NORTH AREA INLETS, STATIONS 64+40L and 65+80L

40. Drainage of the North Area (NA) is aided by three storm sewer systems which discharge into two side channel inlets on Bear Creek. The North Area is divided into three subsections; NA-1, NA-2, and NA-3 which are shown on Plate B-2.

41. Runoff from subsection NA-1 is aided by a storm sewer system about 1,800 feet long and up to 24-inches in diameter that discharges into a small concrete lined side channel inlet with a base width of about 2 feet. The channel depth varies from about 4 feet to 6 feet and has a channel length of about 640 feet. Runoff from subsections NA-2 and NA-3 is aided by a sewer system about 1.5 miles in length and includes a 1,500 foot long, 48-inch RCP interceptor, that discharges into a parabolic concrete lined side channel inlet with a width of about 36 feet. The existing channel has a length of about 280 feet with depths varying from 7 feet to 8 feet. Because the modified main channel is wider and has a different alignment from existing conditions, the inlet channels are slightly reduced in length.

42. Flow from these two channels enter the modified main channel via an overflow embankment designed in accordance with TR 2-650 (reference i). The embankments convey flow from the point of interception by the modified main channel down to the low flow channel invert. This point of interception is near the main channel top of bank for the NA-1 outlet and is at the stream side edge of the high flow bench for the combined NA-2 and NA-3 outlet. Embankment designs are presented in the SIDE CHANNEL INLET OVERFLOW EMBANKMENTS portion of this section.

43. Because the side channel overflow embankment crest lengths are greater than the existing channel bottom widths, channel transitions are provided between the embankment and the existing side channel. The overflow embankment crest length for the NA-1 outlet is 20 feet (see Table B-20) and the existing channel bottom width is about 2 feet. The channel transition is 54 feet long and flares at a rate of 1-horizontal to 6-longitudinal with side slopes of 1V:3H. The existing concrete channel is removed from the transition area and is replaced by a blanket of 12-inch Type A riprap along the channel bottom and 18-inch Type B along the side slopes. The 12-inch Type A riprap is adequate for scour protection; however, 18-inch Type B is used on the side slopes because of possible vandalism.

44. The existing parabolic concrete inlet for the combined NA-2 and NA-3 discharge is removed and replaced with a preformed scour hole at the existing 48-inch storm sewer outlet. The preformed scour hole at the exit portal dissipates the outflow energy and prevents downstream erosion. The scour hole is designed in accordance with HDC Charts 722-6 and 722-7 (reference j). The peak discharge of 335 cfs for the combined NA-2 and NA-3 areas includes overland flow and therefore can not be assumed as the pipe discharge. For design of the scour hole, the pipe discharge is based on a conservatively estimated value of 15 feet available head which would produce a discharge about 250 cfs. Table B-19 shows the preformed scour hole dimensions and riprap design.

TABLE B-19
Preformed Scour Hole Design
Storm Sewer Outlet for North Areas #1 and #2

Discharge (cfs)	D_0 Diameter Discharge Pipe (ft)	1/2 D_0 Depth Scour Hole (ft)	2 D_0 Basin Width (ft)	3 D_0 Basin Length (ft)	Side Slopes	Riprap Size D_{50} (ft)	Riprap Weight W_{50} (lbs)
250	4	2	8	12	1V:3H	0.80	45

45. Based on the W_{50} minimum riprap requirement, the scour hole is protected by a blanket of 18-inch Type B riprap.

Type B Riprap Gradation

	Percent lighter by weight (lbs)					
	100		50		15	
d_{100}	Max	Min	Max	Min	Max	Min
18"	292	117	86	58	48	18

46. The 8 foot scour hole basin width transitions to the 25 foot overflow embankment crest length (see Table B-20) within the distance available (about 90-feet), flaring at a rate greater than 1-horizontal to 6-longitudinal.

SIDE CHANNEL INLET OVERFLOW EMBANKMENTS

47. The side channel inlet overflow embankments are designed in accordance with TR 2-650 (reference i). The methodology of embankment design is outlined in the SWALE DESIGN portion of the INTERIOR FLOOD CONTROL FEATURES - LEVEED AREA section of this Appendix.

48. The following model tested stone gradation (Type A1) meets the stability requirements for the prototype conditions of the three side channel inlet overflow embankments.

Stable Stone Gradation

d_{100}	W_{100}	W_{50}	W_{15}
24"	690	190	28

As with the swale overflow embankments presented earlier, the embankments are constructed of 27-inch Type F riprap.

Type F Riprap Gradation

	Percent lighter by weight (lbs)					
	100		50		15	
d_{100}	Max	Min	Max	Min	Max	Min
27"	984	394	292	197	146	62

Note: Bedding requirement is shown in Table A-17 of Appendix A.

49. The embankments have 1V:3H side slopes; however, the design unit discharge is based on a rectangular section to assure a conservative value for crest length. Maximum stable unit discharges were determined from Plate 48, Limits of Stability for Nonaccess Type Embankment, of TR 2-650. Since no data points are available for a unit discharge of 5-cfs per foot, the access type curve of Plate 47 was superimposed to determine allowable tailwater crest heights for Type A1 stone gradation.

TABLE B-20
Side Channel Inlet Embankments
Crest Designs

Embankment Location		Peak Discharge	Crest Elevation	Crest Length (feet)	Design Unit q (cfs/ft)	Crest Width (feet)	Maximum Unit q cfs/ft Plate 48
SP	44+75R	36	996.0	7/11*	5.1	12	6.0
NA-1	64+40L	86	996.0	20	4.3	20	5.0
NA-2+3	65+80L	335	993.0	25	13.4	22.5	15.0

* Embankment crest expands to meet the bottom width required for the standard end sections provided for the bituminous path crossing.

50. All embankments have a downstream sloping face of 1V:4H. The Slatterly Park embankment slopes down to the landward edge of the modified channel high flow bench. A riprap protected channel 7 feet wide and 1 foot deep, with 1V:3H side slopes, conveys the flows across the high flow bench to the interlocking concrete slope protection of the low flow channel. The riprap gradation for the high flow bench channel is the same as that for the overflow embankment; 27-inch Type F.

51. The North Area embankment (NA-1) crest, at station 64+40L, is about 1 foot below the high flow bench elevation. The embankment slopes downward through the high flow bench to the modified channel invert. The North Area embankment (NA-2+NA-3) crest, at station 65+80L, is about 4 feet below the high flow channel bench and extends the full width of the bench (22.5 feet). The embankment then slopes downward to modified channel invert. Table B-21 shows the design parameters of the embankment slopes.

TABLE B-21
Side Channel Inlet Embankments
Slope Designs

Embankment Location		Crest Elev.	Slope	Channel Invert Elev.	Crest Height feet	Tail-Water Elev.	Estimated Tailwater to Crest (ft)
SP	44+50R	996.0	1V:4H	986.0*	3.0*	993.2*	-2.8
NA-1	65+20L	996.0	1V:4H	990.0	6.0	992.6	-3.4
NA-2+3	66+40L	993.0	1V;4H	990.3	2.7	992.6	-0.4

* The high flow bench is at elevation 993.0 feet NGVD.

52. Tailwater to crest heights are determined from the 1-percent chance storm elevations occurring on Bear Creek at the time of peak discharges at the side channel inlets (see Table B-20).

STORM SEWER OUTLET DESIGN

53. The major changes to the storm sewer outlet designs from the GDM are shown in Table B-2. Four types of storm sewer outlets are proposed to convey flows from the existing storm sewers to the modified channel. They are,

Type 1: Drop manholes with RCP outlet and standard end section
Type 2: Concrete headwalls with straight drop to concrete basin
Type 3: Standard end sections - outlet onto exposed rock
Type 4: Drop manholes with beehive inlets

Existing pipes are extended when necessary due to channel realignment.

54. Table B-22 shows the location, diameters, and design elevations for the inlet and outlet pipes for proposed Type 1 drop manholes. All outlet pipes are RCP with minimum diameter of 18-inches and have flared outlets. The pipes are sloped to provide velocities of 3-fps when flowing 1/4 full (reference c and h). The outlet inverts are located 3 feet above the main channel invert and lie on existing bedrock when ever possible. Scour protection for the outlet is either exposed bedrock or the proposed channel scour protection.

TABLE B-22
Type 1 Storm Sewer Outlets
Drop Manholes

	Inlet Pipe				Outlet Pipe			Channel
Station	Type	Dia. (in)	Invert Elev.	Slope ft/ft	Dia. (in)	Invert Elev.	Percent Slope	Invert Elev.
5+83R	RCP	15	978.0	.028	18	974.1	.444	972.1
7+96L	RCP	21	979.2	.025	21	975.6	.360	972.6
10+37R	VCP	15	984.6	.017	18	978.0	.444	973.1
10+88L	RCP	18	985.6	.008	18	981.0	.444	973.3
13+96R	VCP	15	987.6	.007	18	981.0	.444	977.1
16+95R	VCP	15	987.5	.012	18	982.0	.444	979.0
23+78R	RCP	15	988.2	---	18	983.4	.444	980.9
39+78R	VCP	12	995.7	.008	18	990.0	.444	985.1
45+84R	CMP	36	994.2	.005	36	989.1	.180	986.1
51+49R	RCP	30	996.8	.006	30	990.4	.230	987.4

Notes: 1. Outlet pipe at station 5+83R is only 2 feet above the channel invert due to the elevation of the bike path it passes beneath.
2. Outlet pipe at station 23+78R extends to catch basin manhole at station 24+80R and enters main channel through the retaining wall upstream of 6th St SE bridge.
3. Outlet pipe at station 39+78R is trenched into the existing rock to provide 1 foot of cover for the high flow bench.

55. Table B-23 shows the existing storm sewer locations, diameters, and design elevations of the Type 2 outlets. Curtain walls are provided when necessary to retain riprap slope protection near the outlet.

TABLE B-23
Type 2 Storm Sewer Outlets
Concrete Headwalls

Station	Type	Dia. (in)	Outlet Invert ft NGVD	Slope ft/ft	Rock Elev. ft NGVD	Channel Invert ft NGVD	Drop from Invert to rock (ft)
14+17L	RCP	24	984.4	.004	982.0	978.1	2.4
31+15R	RCP	18	991.3	.007	988.0	983.2	3.3

56. Three of the existing storm sewer outlets lie very close to the existing bedrock elevations. Therefore, a headwall is not required at these locations. The existing pipes are fitted with standard end sections that are supported by concrete sills. Flow from the pipes then discharge onto the exposed bedrock. Table B-24 shows the locations, diameters, and design elevations of the Type 3 outlets.

TABLE B-24
Type 3 Storm Sewer Outlets
Standard End Sections - Outlet onto Exposed Bedrock

Station	Type	Dia. (in)	Outlet Invert	Slope ft/ft	Rock Elevation	Channel Invert
26+80L	RCP	12	990.5	.028	990.0	981.9
27+60R	CMP	12	990.8	.016	990.0	982.2
30+60L	CMP	15	992.0	.013	991.0	983.1

57. The east and west bound bridges of US Highway 14 have vertical concrete abutments. Vertical concrete walls are proposed to connect the abutments thus improving flow conditions through the bridge. The walls however, cut off the existing inlet channels of the highway median. Highway U-turns cross the median east and west of the bridge and have 18-inch culverts that convey flow down the median. Flow from the median will enter the channel via drop manholes with a beehive inlet and an 18-inch RCP outlet extending through the concrete walls. The outlet pipe on the right bank passes beneath the recreational concrete pathway. Both outlet pipe inverts are 3 feet above the modified channel invert. The outlet pipes are sloped to provide velocities of 3-fps when flowing 1/4 full.

58. Flows from the ditch located north of US Highway 14 on the right bank will be conveyed beneath the recreational concrete pathway via a beehive inlet and drop manhole. Table B-25 shows the diameters and design elevations of the Type 4 outlets.

TABLE B-25
Type 4 Storm Sewer Outlets
Drop Inlets

Station	Inlet Elevation	Outlet Invert Elevation	Type Pipe	Dia. (in)	Percent Slope	Channel Invert ft NGVD
61+33R	1000.0	992.1	RCP	18	.444	989.1
62+22R	1002.0	992.3	RCP	18	.444	989.3
62+22L	1002.0	992.3	RCP	18	.444	989.3

REFERENCES

The interior flood control design was performed using the following references:

a. Design Memorandum No. 1, Phase 2, General Project Design, Flood Control, South Fork Zumbro River, Rochester, Minnesota, September 1982.

b. EM 1110-2-1410, "Interior Drainage of Leveed Urban Areas: Hydrology", 3 May 1965.

c. TM 5-820-4, "Drainage for Areas Other Than Airfields", October 1983.

d. National Weather Service Technical Report No. 40, "Rainfall Frequency Atlas of the United States", May 1961.

e. National Weather Service HYDRO-35, "Five- to 60-Minute Precipitation Frequency for the Eastern and Central United States", June 1977.

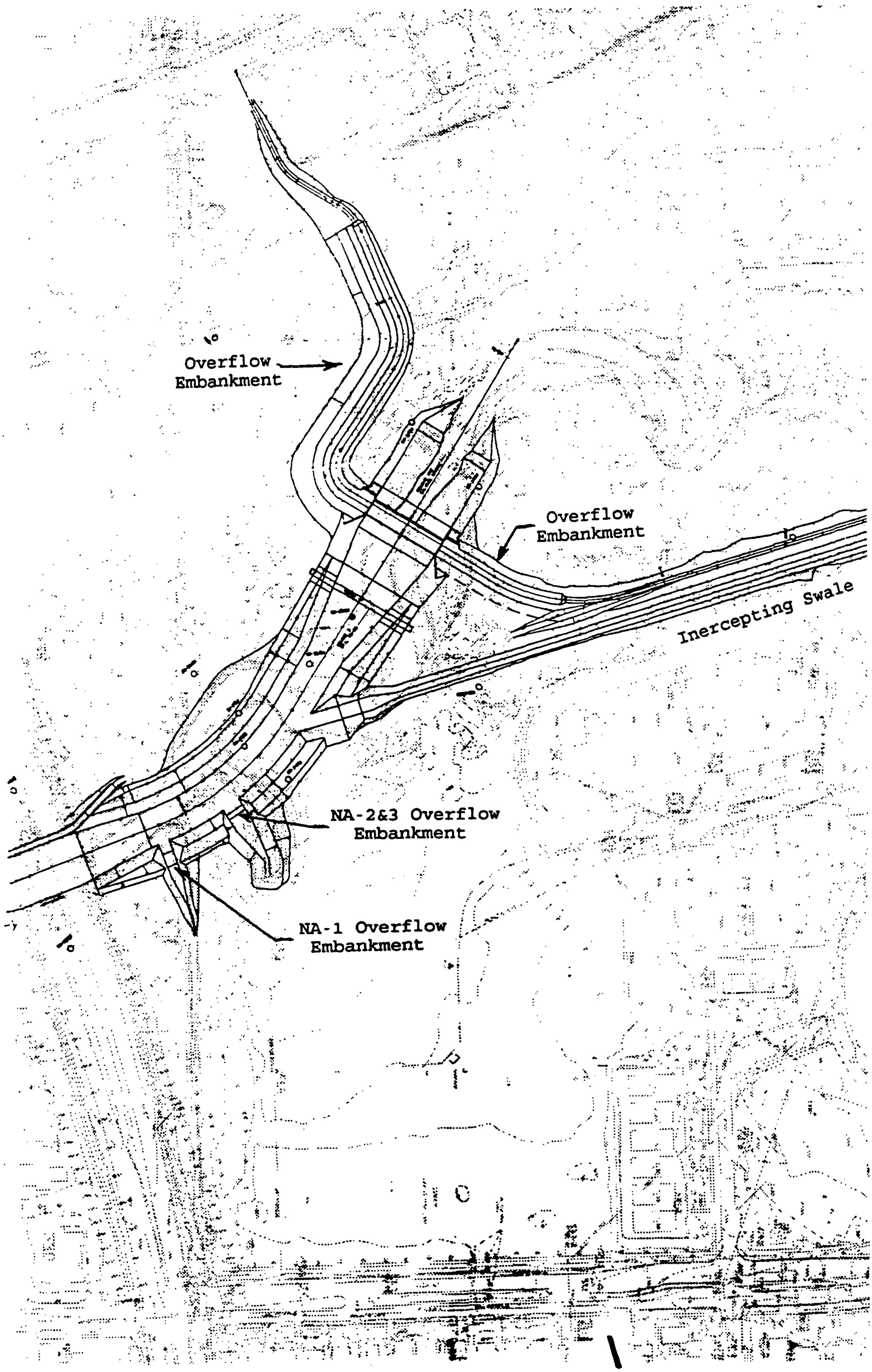
f. Soil Conservation Service Technical Release No. 55, "Urban Hydrology for Small Watersheds", June 1986.

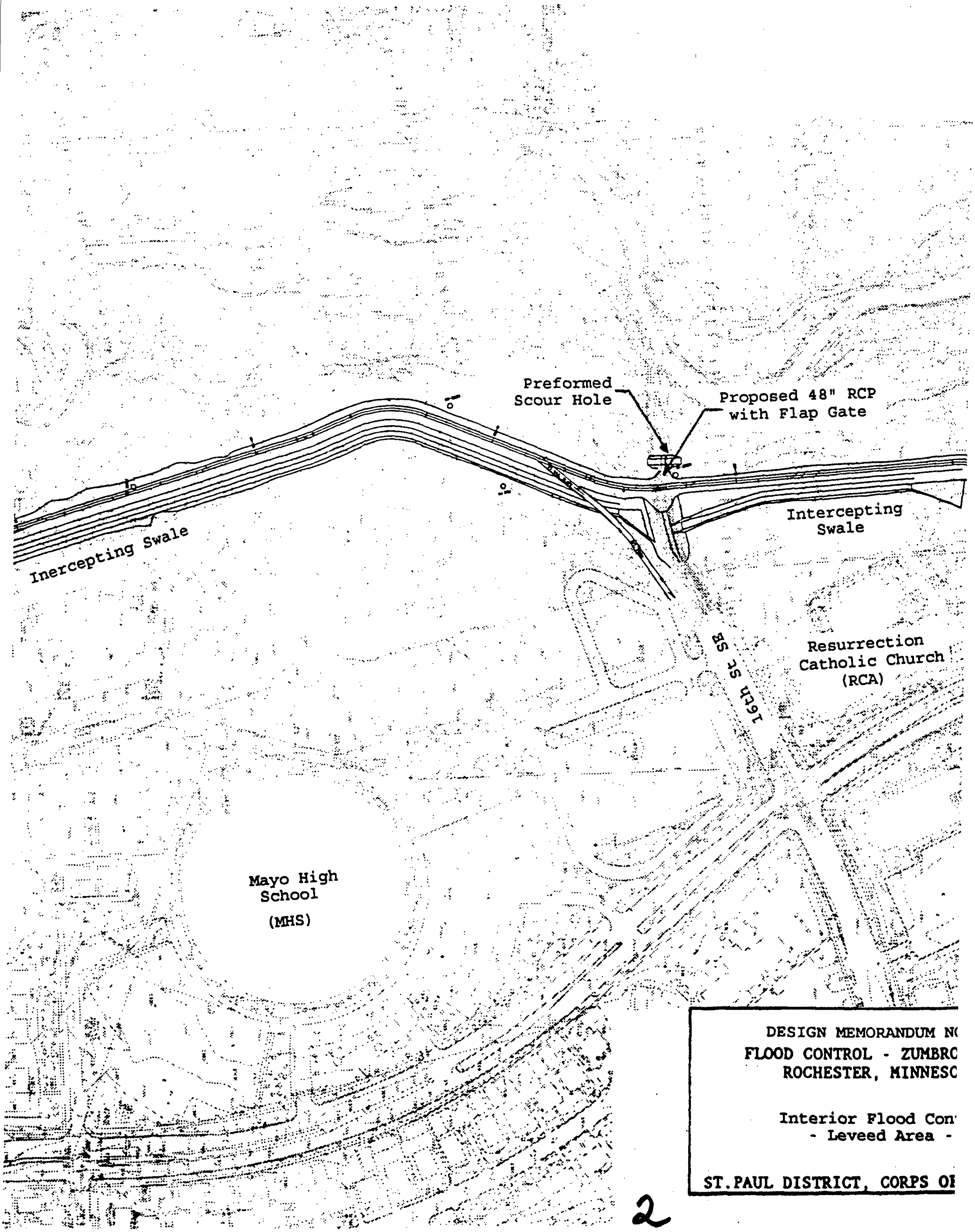
g. EM 1110-2-1601, "Hydraulic Design of Flood Control Channels", 1 July 1991.

h. Cretex Concrete Products Catalog, "Hydraulics of Sewers" and "Hydraulics of Culverts", Cretex Companies Inc., 1971.

i. Technical Report No. 2-650, "Stability of Riprap and Discharge Characteristics, Overflow Embankments, Arkansas River, Arkansas; Hydraulic Model Study", Waterways Experiment Station, June 1966.

j. Hydraulic Design Criteria, Volumes 1 and 2, Waterways Experiment Station, June 1988.


Overflow Embankment
Overflow Embankment
Inercepting Swale
NA-2&3 Overflow Embankment
NA-1 Overflow Embankment



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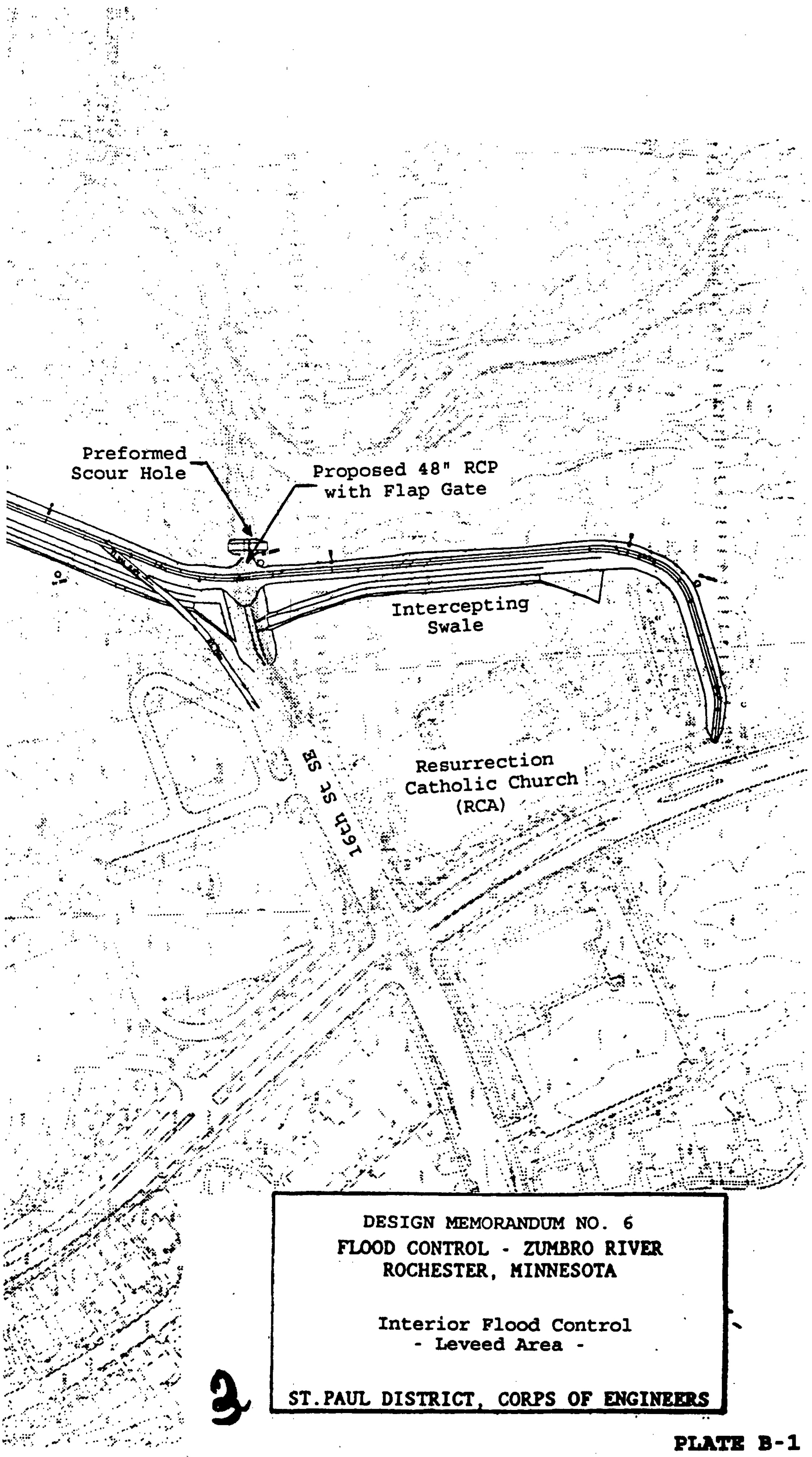
FLOOD CONTROL - ZUMBRC
ROCHESTER, MINNESC

Interior Flood Con'
- Leveed Area -

ST.PAUL DISTRICT, CORPS OI



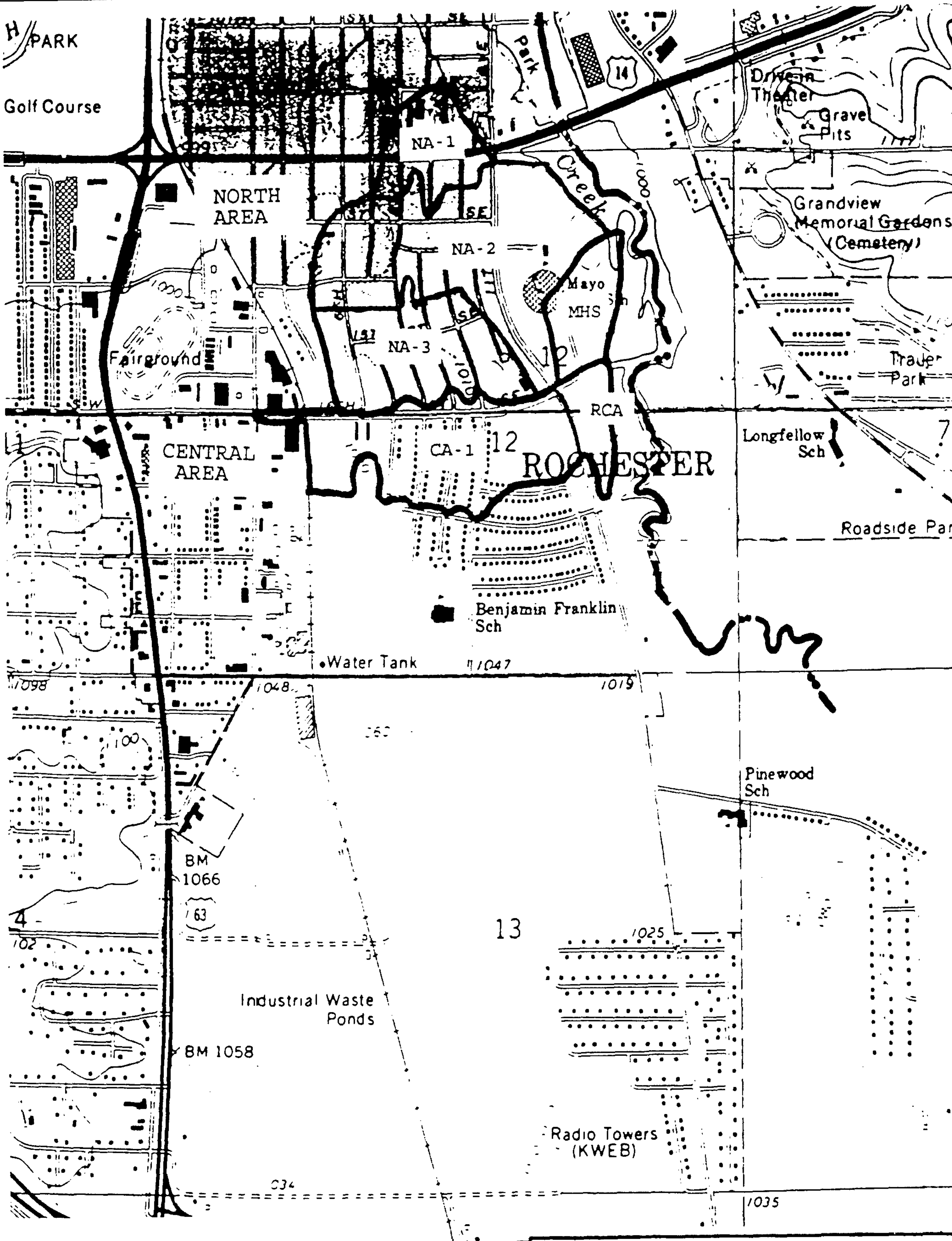
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - ZUMBRO RIVER
ROCHESTER, MINNESOTA

Interior Flood Control
- Leveed Area -

ST.PAUL DISTRICT, CORPS OF ENGINEERS

3

PLATE B-1



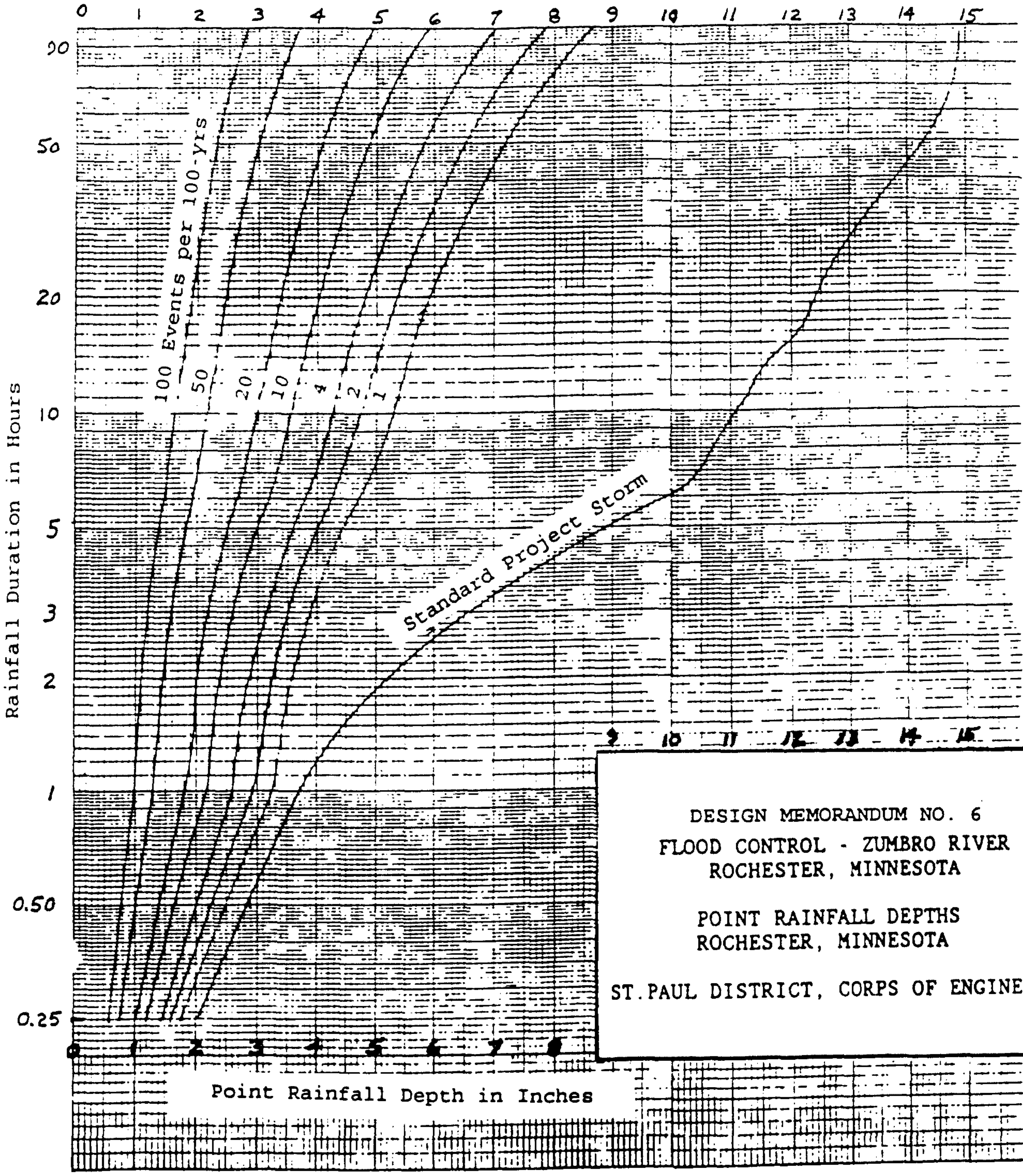
Section Name	Area Acres
NA-1	21.3
NA-2	63.4
NA-3	45.4
CA-1	62.2
MHS	24.2
RCA	8.3

DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - ZUMBRO RIVER
ROCHESTER, MINNESOTA

INTERIOR FLOOD CONTROL
CONTRIBUTING WATERSHEDS
BEAR CREEK

ST. PAUL DISTRICT, CORPS OF ENGINEERS

PLATE B-2

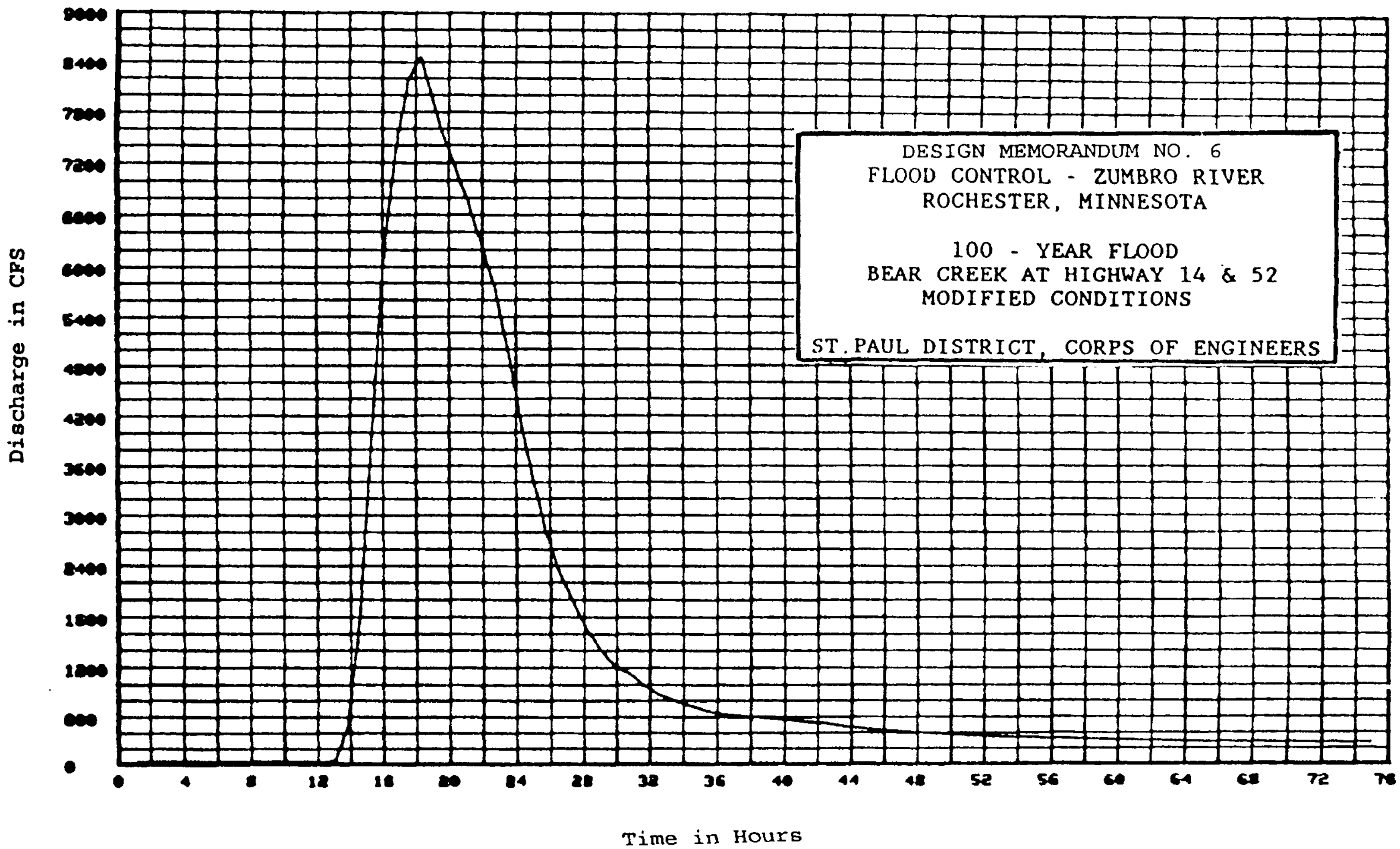


DESIGN MEMORANDUM NO. 6

FLOOD CONTROL - ZUMBRO RIVER
ROCHESTER, MINNESOTA

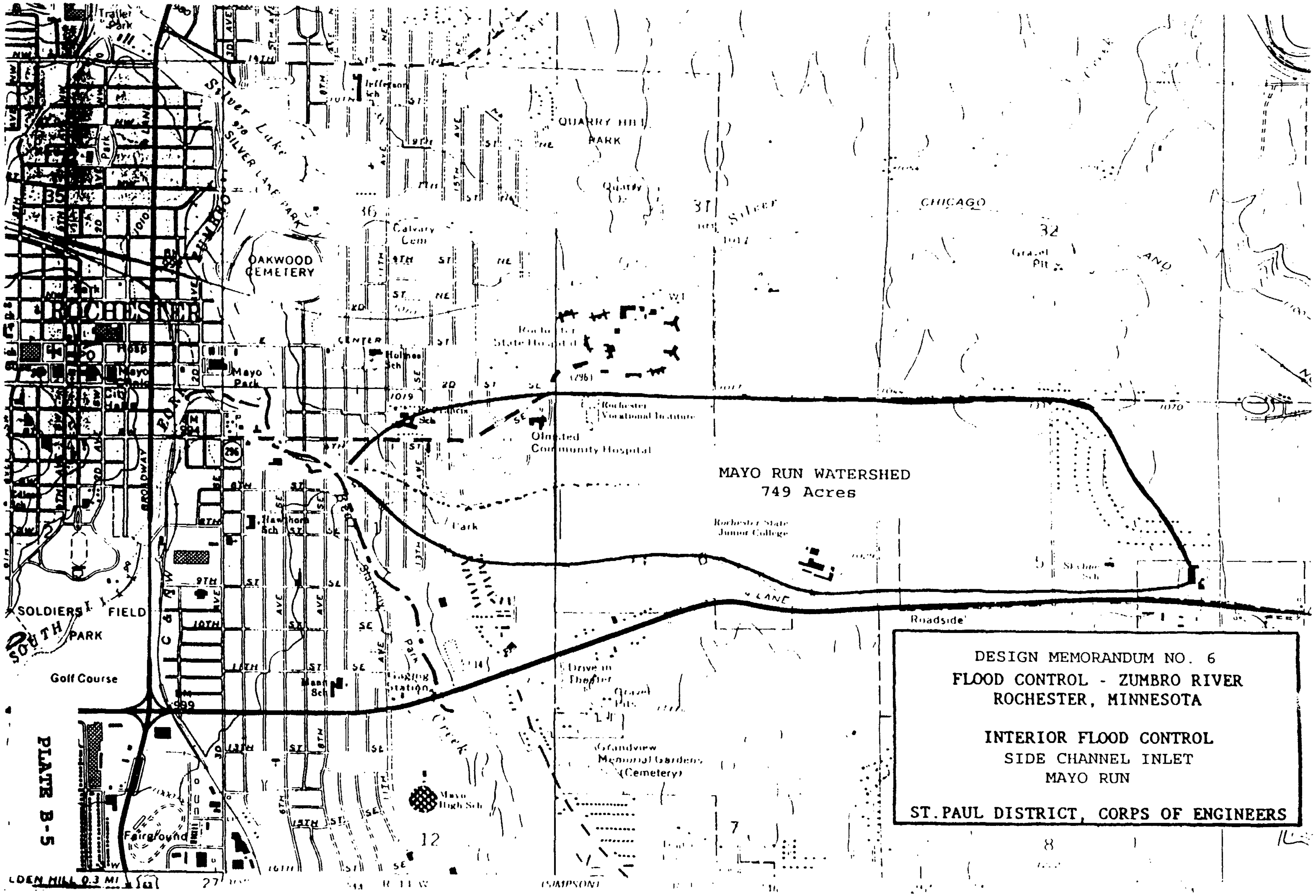
POINT RAINFALL DEPTHS
ROCHESTER, MINNESOTA

ST.PAUL DISTRICT, CORPS OF ENGINEERS



DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - ZUMBRO RIVER
ROCHESTER, MINNESOTA
100 - YEAR FLOOD
BEAR CREEK AT HIGHWAY 14 & 52
MODIFIED CONDITIONS
ST.PAUL DISTRICT, CORPS OF ENGINEERS
Discharge in CFS
9000
8400
7800
7200
6600
6000
5400
4800
4200
3600
3000
2400
1800
1200
600
0
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
Time in Hours

PLATE B-4



DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - ZUMBRO RIVER
ROCHESTER, MINNESOTA

INTERIOR FLOOD CONTROL
SIDE CHANNEL INLET
MAYO RUN

ST. PAUL DISTRICT, CORPS OF ENGINEERS

PLATE B-5

APPENDIX C

GEOTECHNICAL DESIGN

APPENDIX C

GEOTECHNICAL DESIGN

TABLE OF CONTENTS

PARAGRAPH	DESCRIPTION	PAGE
1-3	PROJECT DESCRIPTION	C-1
4	GEOTECHNICAL DESIGN CONSIDERATIONS	C-1
5-6	Rock Excavation	C-1
7	Retaining Wall Foundations	C-2
8	Bridge Structure Foundations	C-2
9	Drop Structure Foundations	C-2
10	Levees	C-2
11	Existing Highway Bridges	C-2
12-13	REGIONAL GEOLOGY	C-2
14-18	OVERBURDEN GEOLOGY	C-3
19-21	BEDROCK GEOLOGY	C-4
22	SUBSURFACE EXPLORATION PROGRAM	C-4
23	SEISMIC REFRACTION SURVEY	C-4
24	PROBES	C-5
25-28	BORINGS	C-5
29	LABORATORY TESTING	C-6
30	SUBSURFACE STRATIGRAPHY	C-6
31-33	SITE OVERBURDEN CHARACTERIZATION	C-6
34-39	SITE BEDROCK CHARACTERIZATION	C-7
40	HYDROGEOLOGY	C-8
41-42	ENGINEERING PROPERTIES OF MATERIALS	C-8
43	TOPSOIL AND FILL SOILS	C-8
44-50	GRANULAR SOILS	C-8
51-52	SEMI-PERVIOUS AND PERVIOUS FILL	C-10
	BEDROCK AND DRAINAGE FILL	C-10
53-57	Index and Strength Properties	C-10
58	Slope Forming Characteristics	C-11
59-60	Durability	C-11
61	Foundation Quality	C-12
62-64	RIPRAP AND BEDDING	C-12
	DESIGN ANALYSIS	C-12
	UPSTREAM DROP STRUCTURE SEEPAGE	C-12
65	Construction Features	C-12
66	Method of Analysis	C-13
67	Parameters	C-13
68	Design Conditions	C-13
69-70	Summary	C-13

TABLE OF CONTENTS Cont.

PARAGRAPH	DESCRIPTION	PAGE
	DOWNSTREAM DROP STRUCTURE SEEPAGE	C-13
71	Construction Features	C-13
72	Method of Analysis	C-14
73	Parameters	C-14
74	Design Conditions	C-14
75-76	Summary	C-14
	TIE-BACK LEVEE SEEPAGE	C-15
77-80	Construction Features	C-15
81	Method of Analysis	C-15
82	Design Conditions	C-15
83-84	Summary	C-16
85-87	RETAINING WALLS AND DROP STRUCTURES	C-16
88	Settlement	C-16
89-90	Frost Considerations	C-17
	CHANNEL BANK SLOPE STABILITY	C-17
91-92	Methods of Analysis	C-17
93-94	Design Conditions & Soil Parameters	C-18
95-97	Stability Results	C-18
98	Comparison with Other Criteria	C-19
99	PEDESTRIAN PATHS	C-19
100	RIPRAP BEDDING	C-19
101-104	Piping Potential	C-19
105	STREAM BED EROSION	C-21
106-107	Rock	C-21
108-109	6th Street Bridge	C-21
110-112	Silt and Rock	C-22
113	SCOUR PROTECTION ALTERNATIVES	C-22
114-115	COST ESTIMATES FOR BEAR CREEK	C-22
116-121	Maintenance	C-23
	DESIGN METHODOLOGY	C-23
122-124	Permissible Velocities	C-23
125-126	Uplift Potential	C-24
127	Bedding for Interlocking Slope Protection	C-25
128	Effect of Ice	C-25
129-133	PROVISIONS INCORPORATED IN BEAR CREEK	C-26
	CONSTRUCTION CONSIDERATIONS	C-26
134	ROCK REMOVAL PLAN	C-26
	EXCAVATION METHODS	C-27
135-137	Ripping	C-27
138	Blasting Characteristics	C-27
139	Other Excavation Methods	C-28
140-141	Rock Exc. Close to Exist. Structures	C-28
142	Character of Excavated Rock	C-28
143-145	GAS MAIN	C-28
146	TEMPORARY EXCAVATION CONSIDERATIONS	C-29
147-149	CARE OF WATER AND CONSTRUCTION DEWATERING	C-29

TABLE OF CONTENTS Cont.

PARAGRAPH	DESCRIPTION	PAGE
150	SOURCE OF CONSTRUCTION MATERIALS	C-30
151	SEMI-PERVIOUS FILL FOR RETAINING WALLS	C-30
152-153	GRANULAR MATERIALS AND AGGREGATES	C-30
154	DISPOSAL AREAS	C-30
	REFERENCES	C-31

TABLES

NUMBER	TITLE	PAGE
C-1	Stage 2A - Direct Shear Test Results	C-9
C-2	Upstream Drop Structure Uplift Factor of Safety	C-13
C-3	Downstream Drop Str. Uplift Factor of Safety	C-14
C-4	Materials with P_{40} > 80%	C-20
C-5	Boring Summary	C-33
C-6	Bedrock Probe Summary	C-36
C-7	Riprap Gradations by Weight	C-38
C-8	Required Bedding Thickness and Riprap Types	C-38
C-9	Bedding Gradations	C-39
C-10	Soil Classification Record Sheet	C-40
C-11	Summary of Classification Tests	C-44
C-12	Soil Parameters	C-45

PLATES

NUMBER	TITLE
C-1	BEAR CREEK - BORING LOGS 81-31M THRU 81-33M
C-2	BEAR CREEK - BORING LOGS 81-34M THRU 81-41M
C-3	BEAR CREEK - BORING LOGS 89-244M THRU 89-250M
C-4	BEAR CREEK - BORING LOGS 89-251M THRU 89-257M
C-5	BEAR CREEK - BORING LOGS 89-258M THRU 89-264M
C-6	BEAR CREEK - BORING LOGS 89-266M THRU 89-273M
C-7	BEAR CREEK - BORING LOGS 89-274M THRU 89-276M, 90-281M, 90-282M, 91-295M, 92-296M
C-8 - C-14	RIPRAP AND BEDDING GRADATION CURVES
C-15 - C-18	CRITICAL FILTER CRITERIA CROSS SECTIONS
C-19	SCOUR PROTECTION COST ESTIMATES
C-20	PERMISSIBLE VELOCITY FOR TURF
C-21 - C-49	GRADATION CURVES

GEOTECHNICAL CALCULATIONS

DESCRIPTION	PAGE
UPSTREAM DROP STRUCTURE	C-46
DOWNSTREAM DROP STRUCTURE	C-55
LEVEE	C-66
SLOPE STABILITY	C-90
SOIL PARAMETERS	C-100

APPENDIX C

GEOTECHNICAL DESIGN

PROJECT DESCRIPTION

1. Stage 4 of the Rochester Flood Control Project consists of approximately 7000 feet of river channel modification on Bear Creek. The Stage begins approximately 200 feet upstream of the Zumbro River confluence and extends upstream of U. S. Highway 14.

2. Channel modifications include: 1) lowering the existing channel bottom to provide for low and high flow channels, 2) construction of reinforced concrete cantilever retaining walls and wing walls on the channel banks, 3) construction of two drop structures, and 4) revetment protection of the channel bottom and side-slopes. The project also includes replacement of three pedestrian bridges, construction of a tie-back levee from the upstream drop structure, and development and modification of pedestrian and bicycle trails.

3. This appendix includes written descriptions, tables, plates and sample calculations to describe the geotechnical aspects of the project. The major sections of this appendix describe the regional topography and geology, discuss the subsurface exploration and laboratory testing programs, describe the site geology, present the selection of engineering design parameters, and discuss the geotechnical design of the major features of the project. Tables, plates and sample calculations follow the text.

GEOTECHNICAL DESIGN CONSIDERATIONS

4. The GDM (Design Memorandum No. 1, Phase 2, General Project Design, South Fork Zumbro River, Rochester, Minnesota, dated September 1982) serves as the basis for the project. Modifications to the project due to geotechnical concerns during the Bear Creek design memorandum have been minor. The general characteristics of the overburden and bedrock, obtained from subsurface investigations performed after the GDM was prepared, supplement information contained within the GDM. No significant changes have been made to the general geology as described in the GDM. The depth to bedrock along the river channel has been further refined, especially in those areas where the existing bedrock is above the proposed channel bottom. The soil and rock parameters, for use in structural design, were modified slightly, from those discussed in the GDM, to reflect the specific subsurface conditions along Stage 4. Specific areas that have included further analysis include:

<u>Rock Excavation</u>

5. Approximately 59,000 cubic yards (cy) of bedrock will be excavated during construction of this reach, consisting of approximately 56,200 cy of channel rock excavation and 2,800 cy of structural rock excavation for retaining walls.

6. Excavation of bedrock will be required between stations 12+00 and 50+00 to achieve design grades for the channel invert. The maximum depth of rock excavation will be approximately 10 feet. Typical bedrock excavation depths will range from 6 to 8 feet.

Retaining Wall Foundations

7. The bridge abutments and drop structures are generally accompanied by wing walls for flow transition. The walls will generally consist of concrete cantilever retaining walls founded on either bedrock or native granular soils. The geotechnical design parameters appropriate for design of the retaining walls are presented under ENGINEERING PROPERTIES OF MATERIALS.

Bridge Structure Foundation

8. Three pedestrian bridges will be constructed to cross the river channel. The geotechnical design parameters for the pedestrian bridge abutment foundations are presented and discussed.

Drop Structure Foundation

9. A drainage blanket will be used under the upstream drop structure to relieve uplift due to seepage. The design of the drainage blanket and its role within the foundation for the drop structure is discussed.

Levees

10. A tie-back levee is being constructed to protect a low area of residences near the upstream end of the project. The selection of the levee configuration and the uplift and under-seepage analyses are presented.

Existing Highway Bridges

11. The existing U. S. Highway 14 bridges and the 4th Street bridge are each three-span bridges with two rows of piers within the river channel. The existing bridge abutments and pier foundations are pile supported. Concrete scour protection is being used to protect the piers on Highway 14. The 4th Street bridge foundations will remain below the riprap channel lining. The 6th Street bridge is also a three-span bridge with two rows of piers within the river channel, but the foundations are spread footings cast on rock. The 6th Street bridge is discussed under paragraphs 108 and 109.

REGIONAL GEOLOGY

12. The city of Rochester is located in a maturely dissected till plain of the central lowlands physiographic province. The South Fork of the Zumbro River is joined by Bear Creek, Silver Creek and Cascade Creek within the corporate city limits. These streams have steep gradients and radiate from Rochester to the east, south and west in a well-developed dendritic pattern which allows rapid drainage from the entire basin area of 304 square miles. Although they originate as subtle features on the highlands 9 to 22 miles from Rochester, these main streams are joined by numerous tributaries and their valleys become increasingly wider and deeper until they are cut more than 200 feet below the surrounding uplands.

13. Bear Creek is typical of these tributary streams and enters the South Fork of the Zumbro River in the southwestern part of the city. The floodplain

of Bear Creek varies from approximate elevation 990 to 1005 feet within the project limits. (All elevations in this report are referenced to the N.G.V.D. 1929 adjusted vertical datum.) At the confluence of Bear Creek and the South Fork of the Zumbro River, their floodplains coalesce; therefore sharp delineation of individual floodplains is difficult. The mature development of the basin drainage and the merging floodplains provide a natural environment for severe flood potential which is aggravated by the numerous channel obstructions.

OVERBURDEN GEOLOGY

14. The overburden thickness in Olmsted County is generally less than 50 feet. Overburden thickness in excess of 50 feet occurs primarily to the west of Rochester and in the existing river valleys.

15. The uplands in the Bear Creek watershed, and adjacent to Rochester, are mantled by glacial till. The glacial till typically consists of grey calcareous loam to clay loam with some gravel. The till is brown where oxidized in the upper portions. The grey till is older than late Wisconsin. The thickness of the grey till is variable. The thickness has been documented by the Minnesota Geologic Survey to be generally less than 25 feet but extends in excess of 300 feet in a buried valley west of Rochester. Most upland areas also have an overlying layer of loess that is generally less than 5 feet in thickness. Slightly thicker covers of loess are predominant in lobes extending to the northeast and southeast of Rochester. The loess typically consists of uniform bedded silt with some clay and fine sands.

16. The river valleys near Rochester generally consist of alluvial deposits of sand and gravel. The lower portions of the tributary valleys were scoured by glaciation to depths up to 90 feet and subsequently filled with alluvial deposits. The scour patterns in the bedrock are irregular and bedrock elevations can change abruptly. The depth of bedrock along the Bear Creek channel varies from being present at the channel invert to depths about 50^{+} feet below the flood plains. The courses of modern streams through Rochester do not follow older channels known from subsurface data to have been cut much deeper into bedrock. Bear Creek flows on thin bedded dolomite and dolomitic sandstone for several thousand feet upstream of its confluence with the South Fork of the Zumbro River. Bedrock is known to occur at or close to the present channel bottom of the creek between approximate station 12+00 to station 50+00. This bedrock channel bottom is the effective base level of erosion for the upstream sub-basins.

17. The majority of the granular soil deposits in the valleys were probably deposited during retreat of the latest glaciation period when river discharges and water velocities were higher. Recent alluvial deposits, associated with slower moving water, have formed near surface soils consisting of silty sand, silt and clay of varying thickness on the floodplains.

18. The glacial till and alluvium generally extend to bedrock which consists of Devonian and Ordovician shales, dolomites, limestone and sandstones. Intermediate deposits along hillsides consist of colluvium, which typically consists of rock in a silt or sand matrix.

BEDROCK GEOLOGY

19. The rock surface in the Rochester area is known to vary quite rapidly over short distances. It is not uncommon for the rock surface to be exposed in the existing channel and plunge to 30 feet below the channel within a distance of 100 feet. Near the downstream drop structure, the rock elevation is about 945 feet at station 7+00 (boring 81-31M) and rises to about 985 feet at station 15+00 (boring 89-252M).

20. Bedrock underlying the project area is the Prairie du Chien Group which is composed in descending order of thin bedded dolomite of the Willow River member of the Shakopee formation, sandstone of the Root Valley member and thin to thick bedded dolomite of the Oneota formation. Friable sandstone of the St. Peter formation overlies the Shakopee formation and is exposed at numerous locations in the vicinity of Rochester between elevations 1100 and 990. The Prairie du Chien group is underlain by thick units of Cambrian and Precambrian sandstones with lesser amounts of dolomite, shale and siltstone which are well below the influence of the proposed construction.

21. The regional dip of the bedrock is to the southwest at about 10 feet per mile. Within the project area, however, the beds are essentially horizontal with local undulating beds. The existence of faults or other geologically significant features have not been identified, but are not considered to be an impact to, nor impacted by the project. There is a potential for encountering soil filled open rock joints or small solution cavities.

SUBSURFACE EXPLORATION PROGRAM

22. A total of 45 machine borings and 1 auger boring have been completed to date on the Bear Creek reach. A summary of the borings performed to date may be found on Table C-5. Locations for each boring may be found on Plates 3 through 14 . The detailed logs with appropriate test data and soil and rock descriptions are shown on Plates C-1 through C-7. Testing was performed by the Missouri River Division Laboratory and may be found on Tables C-10 and C-11.

SEISMIC REFRACTION SURVEY

23. A very limited seismic refraction survey was done to gather data on depth to bedrock and seismic velocity of the near surface bedrock. Three seismic lines were run between approximate stations 12+70 to 13+30, 16+70 to 17+60, and 42+50 to 43+40. The seismic data was used to supplement the other subsurface data for developing top of bedrock maps for project design of structures and channel alignment. Due to the presence of a thin layer of weathered rock at the rock/soil interface and extensive rubble in the downstream reach, the absolute depth and computed seismic velocities of the sound bedrock is not totally reliable. The most useful application of seismic refraction in this area was to determine if rock undulations are significant within the proposed channel excavation. Seismic results as well as borings and probe data indicates that the bedrock surface can be highly irregular and may change in elevation rather suddenly over short distances. Bedrock

surfaces overlain by soils typically show transitional contacts between the soil, weathered bedrock and unweathered bedrock.

PROBES

24. Probes where taken in this reach to supplement boring data. The probes are tabulated on table C-6. Areas that indicated the possible presence of bedrock within the channel excavation where probed. Top of rock elevations were assumed to roughly correlate with the refusal depth. Refusal was called after no advance and 50 blows with a 140 pound hammer dropped 30 inches on AW drill rod. Probes alone are not ideal indicators of the absolute depth to bedrock but like seismic data are good indicators for determining minimum depth to bedrock. The probes were drilled/driven to refusal which was generally inferred to represent approximate top of rock. The probes were extended using 6-inch O.D. hollow stem continuous flight augers or by driving a plugged split spoon sampler. The presence of boulders or other obstructions above the apparent rock surface were sometimes distinguished by auger cuttings and drill performance. Occasional grab samples of the cuttings at the surface were classified for the purpose of correlating the predominant soils at the probe locations with those interpolated from nearby borings. The probes were not extended in accordance with ASTM 1452 and were not intended for identification of soil conditions.

BORINGS

25. The 89-series borings were completed by a contractor, generally using a Mobil B-57 drill rig. The 81-series and 92-series borings were completed by the Corps of Engineers drill crew using a CME-750 drill rig. The M-series borings were advanced with continuous sampling. The borings were extended using either 3 1/4-inch inside diameter (I.D.) or 6 1/4-inch I.D. continuous flight hollow stem augers. A geologist from the Corps of Engineers classified the soils in the field for all borings. Samples were taken from all standard penetration tests (SPT) and some interim samples and preserved in glass jars. All borings were backfilled with cement bentonite grout or ready mix concrete where conditions permitted.

26. Standard penetration tests (SPT) were recorded at 5 foot nominal intervals in general accordance with ASTM 1586, "Method for Penetration Test and Split-Barrel Sampling of Soils." The SPT involves driving an 18 inch split barrel sample tube with 2-inch outside diameter (O.D.). This sampler was driven with a 140 pound CME automatic hammer with a free fall of 30 inches. Continuous sampling was completed by sampling with a 30-inch split barrel sampler having 3 inch O. D. Blow counts were recorded on the field logs for the 3 inch O. D. split-barrel sampling but were not correlated with the SPT test and were not reported on drafted boring logs.

27. Cohesive soils were sampled with a Piston sampler or Dennison tube.

28. Rock Sampling and Testing. After sampling the overburden, rock was continuously sampled on some borings by coring with a Longyear Model NQ Wire Line core barrel. Bentonite drilling mud was used as the drilling fluid. The core barrel was 5 feet long, with a double tube, bottom discharge, and diamond

bit. This barrel produced rock core of approximately 1-7/8 inches diameter. All core samples were descriptively logged in the field by a geologist.

LABORATORY TESTING

29. Geotechnical laboratory tests were performed to aid in determining the physical properties and engineering characteristics of the various soils. The results of grain-size distribution, Atterberg limits, and moisture content tests are presented on Tables C-10 and C-11. Grain-size distribution tests were performed to aid in the classification of granular materials and to verify soil identifications presented on the field logs. The grain-size distribution tests are graphically presented on Plates C-21 through C-50. The liquid and plastic limits and moisture content tests were performed on selected fine-grained materials for use in identifying the soils and estimating their shear strength and compressibility properties. Laboratory testing was completed in accordance with EM 1110-2-1906 by the Missouri River District (MRD)

SUBSURFACE STRATIGRAPHY

30. The subsurface profile along the project alignment generally consists of alluvial sands and gravels overlying bedrock. The upstream portion includes several feet of topsoil and downstream areas generally include varying thicknesses of fill soils that have been pushed in to form the steep riverbanks. Large pieces of construction rubble may also be found in the filled areas.

SITE OVERBURDEN CHARACTERIZATION

31. Existing fill soils are present along the project reach where steep banks are present. This generally includes the residential area from Station 0+00 to Station 40+00. The fill soils consist predominantly of silty sand with some clayey sand and gravelly areas. The relative density of the fill soils is generally medium dense with some loose zones. Some of the existing river banks are strewn with large concrete and rock slabs, particularly from stations 0+00 to 40+00. Boulders have also been placed in the channel beneath some of the existing bridges.

32. The predominant soils encountered in the borings that underlay the surficial fill soils and topsoil consisted of alluvial sands and gravels, typical of the regional overburden geology in the river valleys. The alluvial sands and gravels consist predominantly of fine sand with stratified layers containing varying amounts of gravel, silt and clay. The soils were mostly associated with SP, SM, or SP-SM by the Unified Soil Classification System. There was also a significant amount of soils with an SC or SP-GP classification. The sand grains were predominantly quartz with a sub-rounded shape.

33. The borings indicate the bedrock is generally overlain by one to three feet of highly weathered and fractured rock in a soil matrix. A weathered rock/soil interface was observed on other reaches of the Rochester flood control projects were it consisted of cobble to boulder sized clasts of rock

more or less laying in the bedding planes of underlying intact rock, but heaved and loosened so that the joints and cavities are filled with silt or loam. The rock/matrix ratio is likely to vary with depth and location.

SITE BEDROCK CHARACTERIZATION

34. Bedrock of the Prairie du Chien formation underlies the project area. Strong bedding characteristics and a highly varied lithology distinguish the formation. Seven bedrock corings were extended in this reach. Bedrock data from Rochester Stage 2A, Stage 1B-3 and Cascade Creek is applicable to the Bear Creek project.

35. The bedrock encountered during the subsurface investigations along the channel reach generally consists of inter-bedded layers of dolomitic limestone, sandstone and, less frequently, shale. Sequences of thin to medium bedded limestone range in thickness from less than 1 foot to 6 feet. Sandstone layers are generally less than 2 feet thick. Shale layers are widely spaced and are typically less than 2 feet thick. Generally, the overburden/bedrock interface is gradual, being characterized by a weathered and fractured zone. The extent of weathering varies by location.

36. Rock data obtained from cores and the logging of drill cuttings during the subsurface investigation shows that the bedrock can be broadly grouped into 4 general classifications; limestone or dolomite, shale or siltstone, oolitic limestone, and quartzose sandstone. All of the rock types can be variably silty or sandy and can range from hard to soft depending on the degree of cementation present. Chert beds and inclusions, algal forms, and calcite filled cavities are also common. Some zones of oolitic limestone have been altered and replaced with a siliceous material that is soft and porous with "soil-like" properties. Numerous tight fractures and solution cavities may be found throughout, but are more common near the top of the formation.

37. The rock quality observed in core samples from the subsurface exploration on stage 4 is roughly similar to previous stages of the Rochester project. Stages 1B-3 and 2A both included rock excavation by blasting. The rock quality is based primarily on hardness, compressive strength, jointing and layering.

38. The drill core quality can be expressed by recovery and rock quality designation (RQD). The recovery of cores ranged from 33% (for a 3.0 foot run) to 100%. The recovery typically exceeded 80%. The RQD index was calculated as the recovery of core in lengths greater than 4 inches. The 4 inch core length was applied to core diameters of 1 7/8 inches and 3 inches since the core length appeared to be predominantly due to jointing more so than rock strength. The core barrels consisted of NQ core 1-7/8 inches diameter for the 89-series borings and 3 inches diameter core for the 81-series and 92-series borings. For nominal 10 foot averages, the RQD ranged from a low of 31% (for a 8.6 foot run) to 71% (for a 9.2 foot run). The weighted average RQD was 48% and the median (for nominal 10 foot averages) was 51.5%.

39. Jointing and fracturing in the bedrock is relatively closely spaced. Fractures are generally oriented horizontally and are primarily controlled by

bedding planes. The individual beds typically alternate frequently between the various rock types. Generally, bedding is horizontal, but can be locally wavy or undulating. Bedding thickness ranges from laminated to thick bedded. Tight vertical fractures are relatively common in this rock unit as observed from the regional geology and other stages of the Rochester flood control projects. Recovery and RQD values for the bedrock did not show an increase with depth. In some cases, RQD values decrease with depth.

HYDRO-GEOLOGY

40. Groundwater discharges into the streams in the region. Within the narrow limits of the proposed construction activity, the water table as observed in soil borings was essentially the same as the river level. Water levels in the construction borings have reflected the corresponding water levels in the nearby creek. Changes in the river level will likely result in rapid corresponding changes in the nearby water table. Localized clay or silt beds, and irregular bedrock contours may create some perched water conditions, but the impact of these features is minor during normal water levels. During periods of heavy precipitation or snow-melt, the gradients of inflow to the river will increase and the effects of some subsurface features could become pronounced. Piezometric data on these effects during high water is not available.

ENGINEERING PROPERTIES OF MATERIALS

41. Engineering properties for in situ overburden were developed for the on-site granular soils, backfill soils and bedrock. A list of soil parameters for structural design are attached with this appendix.

42. Backfill placed behind retaining walls will be compacted in place. However, the compactive effort allowed on fill placed behind walls during construction will be restricted to specific construction equipment to prevent damage to the walls. In addition, as fill is placed behind the wall, lateral deflections of the wall will tend to relieve stresses within the soil mass, thereby effectively decreasing the relative density of the soil. For these reasons, the relative density of backfill placed behind walls is assumed to be loose to medium dense.

TOPSOIL AND FILL SOILS

43. Topsoil exists along the southern portion of the project alignment and existing fill soils and some buried topsoil exist along the northern portion of the project. Proposed structures will be founded at elevations below these soils. Structural backfill will not include organics, debris or cohesive soils. Existing fill soils should only impact the project to the extent of subgrade support for pedestrian trails and effort of excavation.

GRANULAR SOILS

44. Relative densities were estimated for the granular soils based on the standard penetration test (SPT). The correlation proposed by Gibbs and Holtz as presented in NAVFAC 7.1-87 expresses SPT as a function of vertical

effective stress (σ_v') and relative density (D_r). For 143 SPT values obtained from the borings, a mean relative density was determined as 65% with a standard deviation of 16%. This analysis is attached with this Appendix.

45. Shear strength parameters for the granular soils were based on correlations with relative density and from direct shear tests performed for granular soils on stage 2A. The cohesion is assumed to be zero, and an internal friction angle of 33 degrees is considered appropriate.

46. Friction angle (ϕ) is related to soil type and relative density (e) in NAVFAC 7.1-149. This correlation yields a value of ϕ=33 degrees for a SM soil and the following properties:

dry unit weight	γ_d=99 pcf,
void ratio	e=0.69,
relative density	D_r=60%,
specific gravity of the solids	G_s=2.68.

47. The results of 60 direct shear tests performed on soil samples obtained during subsurface investigations on the Rochester Stage 2A project are summarized in Table C-1. The ultimate angle of internal friction increases for the granular soils when compacted. The friction angle for compacted fill soils was conservatively assumed to be the same as for the insitu soils. The soils indicated in Table C-1 as "dense" had a relative density of approximately 100 percent.

TABLE C-1

USCS SOIL TYPE	INTERNAL FRICTION ANGLE (DEGREES) MIN.	MAX.	AVE.	STATE
SP	27	37	33	LOOSE
SP	31	36	34	DENSE
SP-SM	32	35	34	LOOSE
SP-SM	31	37	35	DENSE
SM	30	43	34	LOOSE
SM	30	37	35	DENSE
SC	27	37	33	LOOSE
SC	34	40	37	DENSE

48. Borings were located on both left and right banks of the existing channel. The predominant soils along the channel consist of fine pervious sands. The native sands have some evidence of layering, suggesting the permeability in the horizontal direction may be slightly greater than the vertical direction. However, this layering was not pronounced as observed in samples obtained from the borings.

49. Results of direct shear tests performed on similar soil on the stage 2A reach indicated the internal friction angle to have an average value of 33 degrees for loose SP and SC soils and an average value of 34 degrees for loose SM and SP-SM soils. Low and high values were 27 degrees and 43 degrees respectively. Based on the relatively close location of the two projects and

the similarity of the soils identified based on classification, we have assumed a similar value for Stage 4.

50. The value of the interface friction angle (δ) between concrete and alluvium was selected using NAVFAC 7.2-63 as 26 degrees.

SEMI-PERVIOUS AND PERVIOUS FILL

51. Backfill to be placed behind retaining walls will consist of pervious and semi-pervious fill. The percentage of fines (silt and clay) in the semi-pervious fill will be 10 percent maximum. In general, most of the SP and SP-SM soils indicated on the boring logs will meet this criteria. The (SM), (SC), (ML), (CL), and (GM) soils indicated on the boring logs generally do not meet this criteria. Based on the stratification in the boring logs, it is anticipated the contractor will be able to utilize excavated (SP) and (SP-SM) soils with moderately little effort to provide a source for the semi-pervious fill.

52. Pervious fill will be placed immediately behind retaining walls to reduce the build-up of hydrostatic pressures behind the wall and to minimize frost potential. The pervious fill will be limited to a maximum 5% passing the #200 sieve. This should ensure a fill that is free draining such that no excess hydrostatic pressures will be developed and the height of capillary rise is minimal. Pervious fill is considered to have the same strength parameters as semi-pervious fill.

BEDROCK AND DRAINAGE FILL

<u>Index and Strength Properties</u>

53. The index and strength properties of bedrock encountered in borings on Stage 4 were selected on the basis of field identification and correlation with other stages of the Rochester flood control project.

54. Rock Quality Designation (RQD) for stage 4 generally varied between 30 to 60 percent for 10 foot averages with a weighted average of 48%. For Stage 2A, the values of RQD generally varied between 20 and 70 percent with an average value of 42 percent. Test values of the unconfined compressive strengths of rock core from Stage 2A were between 2,080 and 15,860 psi (pounds per square inch). The shear strength of the rock mass was estimated on the basis of correlations between the unconfined compressive strength of the intact rock core specimens and values of RQD recorded for the rock core. The values of rock properties selected for use in design are as follows:

Rock mass shear strength, c = 50 psi (7200 psf)
Rock mass angle of internal friction = 0 degrees
Saturated unit weight = 160 pcf

55. In areas where walls will be founded on bedrock, drainage fill will be placed above the bedrock as needed for dewatering. This creates potential shear planes within the drainage fill, at the bedrock/fill interface and at the interface with the cast in place concrete footings. The drainage fill

will be poorly graded gravel with a 3/4 inch max size placed in thicknesses ranging from 6 to 12 inches.

56. No shear strength testing has been performed on this type of material. However, a friction angle of more than 35 degrees is expected. Due to the coarse nature of this material, concrete cast on its surface is expected to partially fill its surface voids and adhere/bond with the upper aggregates so that this interface will nearly realize the full mobilized friction angle of the fill. The angle of friction between concrete and drainage fill selected for use in design is 33 degrees. As demonstrated during construction of Stage 1B-3, the rock surface excavated for wall foundations is rough and would realize a friction angle greater than that of the rock joints. The friction angles of all rock joints tested were greater than 33 degrees. The shear strength of the contact of the drainage fill with the roughened bedrock surface was based on engineering judgement and selected to yield a friction angle of 33 degrees. This is a conservative assumption since the rock surfaces after blasting and excavation will be rough and any concrete placed directly on the rock would also mobilize the cohesion in the rock and/or adhesion of concrete to rock.

57. Pedestrian bridge piers and abutments will be founded on drainage fill over sound, unweathered bedrock.

Slope Forming Characteristics

58. The bedrock can be excavated to almost any slope. Slopes formed by ripping will be rough with a probable variation of at least approximately one foot from a neat line. Sculpturing the rock to close tolerances will require special treatment such as line drilling or lightly loaded smooth blasting. Smooth blasting with closely spaced, small diameter holes is preferred over line drilling because of the better control of overbreak at the tops of the holes. Ripping with a dozer may also be a preferable method for achieving tolerances for the slope after blasting to approximate grade.

Durability

59. Homogeneous slabs of the limestone and dolomite compromising the bulk of the rock are very resistant to physical and chemical weathering. However, the inter-bedded seams and layers of uncemented to poorly cemented materials, sandstones, and shales are very susceptible to weathering. Bedrock exposed along the existing channel shows some recession of softer seams. The sandstone and shaly beds are responsible for the majority of this. The macro-structure of the rock is then moderately susceptible to weathering by freeze-thaw action, slaking, and other processes of erosion. The degree of poorly cemented materials in the rock macro-structure (and thus the weathering susceptibility) varies irregularly through the project.

60. Exposed rock should be considered susceptible to erosion. Areas where rock could be exposed include the stream bed and banks of the channel (although at this time, only exposed rock on the stream bed is anticipated). These areas should be dimensioned with some tolerance to allow for some deterioration without sacrificing functional value. (Where minor erosion of the stream bed to form meandering channels during low flow is acceptable, this is not important.) Where permanent retention of slopes steeper that 3H on 1V

is critical, the slopes should be protected if an eventual loss of up to two feet of slope cannot be tolerated.

Foundation Quality
61. The unweathered limestone, dolomite and sandstone rocks provide a good foundation for structures planned for the project. Shale or siltstone beds, poorly cemented sandstone, and oolitic limestone that has been altered and replaced with siliceous material is poor quality rock for bedrock foundation designs due primarily to its susceptibility for deterioration. Design criteria for this project has included consideration of erosion potential of the rock.

RIPRAP AND BEDDING

62. Selection of riprap types was based on the hydraulic design requirements described in appendix A. Riprap gradations and required minimum thicknesses were selected from ETL 1110-2-120, enclosures 1 and 3.

63. The riprap gradations match the gradations that already have been used on other segments of the project. The riprap thickness varies between 12 inches of Type A riprap and 54 inches of Type G riprap. The minimum exposed riprap layer thickness used on the slopes was 18 inches of Type B riprap. This thickness and the corresponding size (from ETL 1110-2-120, enclosure 1) was used because the smaller riprap sizes are considered more susceptible to vandalism, especially in urban areas. Type A riprap was used in the stream bed where the rock will normally be below water and on the slopes where a topsoil cover will be included. Riprap gradations are given in Table C-7.

64. Bedding gradations were designed in accordance with the criteria set forth in EM 1110-2-1913, appendix E. Bedding gradation types 1 and 2 have been used on previous stages. Bedding type 4 has been added since a significant portion of type A riprap will be used, a gradation finer than bedding type 1 will have better filter characteristics for the fine sand and silt prevalent on Bear Creek, and we anticipate the type 4 gradation may be placed in 6 inch layers with satisfactory performance (instead of the 9 inches for bedding type 1). Bedding gradAtions are given in Table C-9.

DESIGN ANALYSIS

UPSTREAM DROP STRUCTURE SEEPAGE

Construction Features
65. The upstream drop structure will be founded on the native alluvial sands. The base of the structure will be about 30 feet above the bedrock elevation. To control water seepage, the structure will include an upstream steel sheetpile cutoff wall. A concrete cutoff wall will be included at the sides and sill wall to reduce the possibility for concentrations of gradient that could cause downstream boils or piping beneath the structure and to confine the native soils beneath the slab. The construction of the concrete cutoff will require dewatering to El. 985 feet. The steel sheetpile will be extended to El. 980.

Method of Analysis

66. The upstream sheetpile cutoff wall was sized using Lanes Creep Ratio. A value for Lanes Creep Ratio of $C_w = 7$ was used, which is appropriate for fine sand. The seepage quantity was determined be method of Fragments (Ref. Harr, M. E.). Piping potential was analyzed by consideration of critical gradient (Ref. Harr). An average gradient was assumed based on the shape factor determined by the method of fragments. The factor of safety for uplift was calculated in accordance with ETL 1110-2-307. Typical calculations are attached.

Parameters

67. The permeability of the alluvial sands was estimated based on correlation with the D_{10} grain size. The D_{10} grain size was determined for 14 samples obtained from 5 borings near the upstream drop structure. Based on a conservative value of the D_{10} grain size of 0.23 mm, correlations with field pumping tests on the lower Mississippi River Valley reported in TM 3-424 indicates an upperbound estimate of 0.3 fpm (0.15 cm/sec) for the horizontal permeability of the alluvial sands.

Design Conditions

68. Three cases were considered for the uplift calculation: A) normal operation - maximum head of about 4.6 feet (at the 5 year event), B) unusual operation - consider maximum head with stop logs in drop wall to form upper pool, and C) extreme maintenance/construction - same as case B with slab dewatered.

Summary

69. The analysis results for uplift are summarized in Table C-2:

Table C-2
Factor of Safety for Uplift

Case	calculated FS	Required FS
A	1.57	1.5
B	1.60	1.3
C	1.29	1.1

70. The seepage beneath the structure is estimated to be less than 0.59 cfm/lf (4.4 gpm/lf). The gradients are rather low. Piping factor of safety was determined to be on the order of 12. A factor of safety of 6 to 7 is recommended for fine sand (Ref. Harr).

DOWNSTREAM DROP STRUCTURE SEEPAGE

Construction Features

71. The downstream drop structure will be founded on rock. To control water seepage during construction and to provide a permanent seepage/uplift relief system, a granular blanket will be placed between the rock and slab. The drop, side and sill walls will be constructed over a concrete cutoff. The concrete cutoffs will be keyed into the rock. Features as shown on the plans include: PVC drain tile in the granular blanket and weep holes in the drop wall to drain seepage, doweled joints at the cutoff wall/slab interface, formed cutoff below sill wall with base intact with rock, and cutoffs below

side walls and drop wall cast intact with rock. It is anticipated the cutoffs can be trenched into the rock by some excavation method to avoid a granular backfill against the cutoffs. Since the rock may brake irregularly depending on the excavation method, it is realized the cutoff may vary in size and the as-built lines may be irregular. The trench surface may require careful preparation to remove voids and overhanging blocks so voids are not created during placement of concrete. The contractor, by choice, constructed the drop structure on stage 2B without forming the cutoff walls, but controlling the excavation similar to that proposed.

Method of Analysis

72. Uplift pressures on the drop structure slab were determined by the line of creep method. The three dimensional effect was accounted for by equating in-flow and out-flow. Calculations are attached with the Appendix. The factor of safety for uplift was calculated in accordance with ETL 1110-2-307.

Parameters

73. The permeability of the drainage fill was approximated by Hazen's equation as 20 fpm (10 cm/sec). The permeability of the rock was not determined by testing, and is estimated to be on the order of 10^{-3} to 10^{-5} cm/sec based on published typical values for sandstone. An upper limit for the sandstone was approximated as 0.2 fpm (10^{-1} cm/sec) by application of Hazen's equation (considering the rock to contain porous and uncemmented layers).

Design Conditions

74. A factor of safety for uplift was checked for 3 cases: 1) maintenance dewatering when the water surfaces are flush with the top of dropwall and sill wall, 2) normal operations has a maximum head of about 5.2 feet (for the 100 year event), and 2A) 100 year event with drains 50% effective.

Summary

75. The analysis results are summarized in Table C-3:

Table C-3
Factor of Safety for Uplift

Case	Calculated FS	Required FS
1	1.26	1.1
2	> 1.8 *	1.5
2A	1.98	1.5

*slab only, without weight of walls

76. The seepage quantity is indeterminant since the flow path is not well defined. It is assumed the majority of the seepage will occur through discrete fractures in the rock. Piping of rock is not considered and piping of the granular blanket is controlled by filtered drain tile.

TIE-BACK LEVEE SEEPAGE

Construction Features

77. The tieback levee will extend about 2850 feet on the left bank with about 250 feet of overflow section and about 900 feet on the right bank with about 550 feet of overflow section. The left bank levee will have a ditch running along the landside toe from approximate stations 3+00 to 24+00 for interior drainage. The ditch and levee will be separated by a berm to keep the alignment straight since the bottom width of the levee will vary depending on the native topography.

78. The soil conditions near the levee vary somewhat from the left and right banks. The left bank levee borings (81-38, 89-249, 89-250, 89-253, 89-254, 89-255, 89-257, 89-258, and 89-276) generally encountered a minimal topsoil cover. Two borings encountered no top stratum, 3 borings encountered a zone of silty sand about 6 inches to 2 feet thick, and 2 borings encountered a layer of clay topsoil about 1 foot in thickness. This layer of surficial low permeability material on the left bank levee is intermittent and relatively thin. It would not be practical to protect this cover soil, so it is considered sacrificial. If uplift were to occur, the soil would crack and permeate water and/or saturate and become muddy. Any damage to landscape would likely be minor. Therefore, the soil stratum is considered to be uniform sand without a surficial zone susceptible to uplift for the analysis.

79. The right bank levee borings (89-275 and 81-40) encountered about 2 feet of black topsoil, ranging from organic sandy silt to organic silty clay. This material may be susceptible to boils/uplift. Visual observations of the steep stream bank that shows signs of recent erosion identified a gradual transition of black topsoil to underlying brown silty sand. In some areas, there are shallow lifts of silty fine sand fill placed over the topsoil layer. There is also a bituminous parking lot at station 5+00 to 6+00, about 70 feet downstream of the toe.

80. Levee slopes will be constructed as 3H:1V on the upstream side and 5H:1V on the downstream side. This is considered a standard design and was not analyzed since there are no unusual conditions identified that would warrant further analysis.

Method of Analysis

81. The left bank levee was evaluated for seepage and uplift by: 1) analytical solutions, 2) flow net and 3) finite element method (FEM) using code SEEPS from Virginia Poly Technical Institute. The analyses assumed a value for the permeability of the alluvial sands of $k_h = k_v = 0.1$ fpm (0.05 cm/sec) based on correlations with the D_{10} grain size. Calculations are attached.

Design Conditions

82. The levees were evaluated for seepage and piping based on assuming there is not tailwater and the levee is at the point of overtopping so as to produce the maximum differential head possible. (The downstream soil is assumed to be saturated to the surface.) However, this is not likely to occur

during a flood event. The calculations include a figure showing "water surface profile elevations" that shows the differential head on the levee that is predicted by hydraulic models for the variable river stages.

Summary

83. The analysis results for seepage indicate a shape factor of $=0.4 is a conservative estimate for estimating total seepage for the left bank levee. Total seepage for the left bank (to station 29+00) is estimated to be about 3.5 cfs for the 100 year flood and 8.1 cfs for overtopping without tailwater. Gradients at the toe are estimated to be less than i=0.3 as recommended for design of seepage berms in EM 1110-2-1901.

84. For the right bank levee, seepage is not critical and is estimated to be on the order of that per unit length as for the left bank levee. Uplift of the topsoil layer and bituminous parking lot are critical. For a simplified section at station 3+00, gradient at the toe is estimated to be about i=0.79 with a head at the toe of 1.58 feet above the ground surface. However, this should be reduced by stripping the topsoil (approximately 2 feet) beneath the levee and downstream stilling basin (most of the right bank levee is overflow section). Along most of the right bank levee, construction will involve excavating to obtain grades for constructing the levee so that the stripping does not compromise extra work.

RETAINING WALLS AND DROP STRUCTURES

85. Wing walls will extend from the bridge abutments at 4th Street, 6th Street and U. S. Highway 14. The bridge abutment wing walls and the side walls for the drop structures will consist of reinforced concrete cantilevered retaining walls. Reinforced concrete retaining walls will also be constructed at the pedestrian bridge abutments and some of the storm sewer outlets.

86. The retaining wall footings at 6th Street and the downstream drop structure will be founded on rock with a layer of coarse drainage aggregate below the concrete for dewatering during construction. Retaining wall footings at 4th Street, U. S. Highway 14 and the upstream drop structure will be founded primarily on native medium dense sands. Possible exceptions noted in the borings include: 1) a layer of buried topsoil and some loose sands at 4th Street that could extend below the wall where the footing steps up, and 2) a layer of clay overlying weathered rock at U. S. Highway 14.

87. Calculations for bearing capacity, lateral wall pressures, and uplift pressures from seepage were completed by the structures department based on soil parameters attached (4 November 1991 memo).

Settlement

88. The downstream drop structure and many of the retaining wall foundations will be founded on drainage fill placed on sound, unweathered bedrock and therefore settlements are expected to be negligible. On the upstream end of the reach, the walls and upstream drop structure will be founded on the medium dense alluvial sands. Settlement of structures founded on the granular soils is not expected to be significant for footings designed with a maximum net bearing capacity of 3000 psf. The subgrade will be

compacted prior to constructing the walls which will reduce the potential for loose zones in the foundation subgrade and therefore reduce settlement that may occur within the sand deposit. A significant portion of the settlement will occur during construction. Wall rotations are expected to be on the order of 0.0005 to 0.002 radians to mobilize the active strength of the wall backfill. This corresponds to a movement of the top of the wall of about 0.1 to 1/4 inch for a 10 foot wall height. Therefore, no distress associated with long-term settlement is expected.

Frost Considerations

89. Design for frost conditions becomes important when attempting to utilize as much on-site excavation material as possible within the construction project. Conditions are such that frost and freezing can be a significant problem since sustained freezing temperatures, a close source of water and moderately frost susceptible soils are all prevalent in the Rochester area. On Stage 2A, alternative wall backfill and insulation schemes were considered as potential measures to eliminate the concerns of ice lens formation on the back face of the retaining wall stems. For Stage 2A, an alternative design method was adopted which consisted of placing pervious material to an elevation of 4 feet above the 2 year water surface elevation in the channel to provide a capillary cutoff for the upper portion of the wall backfill.

90. On Stage 4, the preliminary design consists of placing pervious sand to a nominal thickness of 3 feet adjacent to the wall from the top of footing to 2 feet below finished grade, with a zone of coarse drainage aggregate behind the wall stem, perforated drain pipe and weep holes. This should provide a chimney drain to reduce moisture within the typical zone of frost penetration behind the wall. Backfilling with pervious material is a proven method for reducing frost problems behind retaining walls. It is effective since it provides a soil with low susceptibility for ice lense formation, is not subject to significant capillary action and provides drainage above the water level. Rigid walls (with restrained movement such as the pedestrian paths at the bridge underpasses) that will be founded at or below the normal water level should include an extruded polystyrene foam board insulation near the normal water level.

CHANNEL BANK SLOPE STABILITY

Methods of Analysis

91. UTexas2 was used to determine the effect of a delayed drop of the phreatic surface with the river stage. This incorporated the method of slices using Spencer's method with circular surfaces. The phreatic surface was approximated as a linear surface extending from the toe to different levels in the bank. The factor of safety was determined for different water levels.

92. Since the slope stability varies with the phreatic surface level, an attempt was made to correlate the water level lag with the soil conditions in the banks. With reference to EM 1110-2-1902, Appendix III, the water lag was approximated by Schnitter and Zeller's method for estimating the lowering of the seepage line in embankments with a pervious upstream zone and an impervious core. Schnitter and Zeller's method approximates the water lag as

a function of the drawdown rate, the soil permeability and the soil porosity. For high lag differences immediately after fall of the river stage, seepage conditions would likely be approximated by Schnitter and Zeller's method. It is recognized that for low lag differences after a long time, the correlation is poor since the field conditions at Bear Creek are an infinite pervious bank with a minor amount of continuous seepage, and Schnitter and Zeller's method assumes a finite pervious zone.

Design Conditions and Soil Parameters

93. A cross section was assumed for the stability analysis which is typical for channel banks from Sta. 10+00 to 33+00. This cross section is 2.5H:1V in the lower portion and 3H:1V in the upper portion. The channel side slopes will be cut into sand deposits consisting of native sand and existing fill, and will also be formed by placement of random fill. Soil parameters for the existing sand deposits are discussed in paragraphs 42 - 51, and include moist unit weight of γ_m=115, friction angle of ϕ=33°, saturated unit weight of γ_{sat}=125 pcf and void ratio of e=0.69.

94. Points from the hydrograph for Bear Creek were correlated with the rating curve from the HEC-2 hydraulics model to determine the river stage at different times after the peak flood conditions for the design event. The drawdown velocity is obtained by differentiating the river stage with respect to time.

Stability Results

95. Based on the predominant soils with a permeability in the range of 0.10 fps (0.05 cm/sec), the anticipated lag from the Schnitter and Zeller method is on the order of 1.5 feet. This is not considered to be an accurate estimate, but implies the water level due to drawdown would rapidly approach steady state conditions, which we would estimate to be a maximum in the range of 3 to 4 feet. For lags in this range, the UTexas2 analysis implies the critical failure condition would be shallow sliding unaffected by the phreatic surface. The factor of safety for shallow sliding, determined from infinite slope analysis or UTexas2, is 1.62.

96. The required factor of safety for partial pool with steady seepage is 1.5. This is conservative since semi-rapid drawdown is an infrequent event, but is adopted since water levels in the banks during the design event have not been measured. From the UTexas2 analysis, this corresponds to a water lag of about 9 feet, and from Schnitter and Zeller's method, corresponds to a permeability of about 0.004 fpm (0.002 cm/sec). From correlations with Hazen's equation, this corresponds to a D_{10} grain size of about 0.04mm. This implies that only the (SM) silty sands would be subject to a factor of safety less than 1.5 during the design event.

97. The (SM) soils (subject to a factor of safety less than 1.5 during the design event) would have a minimum factor of safety determined by considering rapid drawdown. The UTexas2 model determined a factor of safety on the order of 1.0 for rapid drawdown. EM 1902 recommends a factor of safety for rapid drawdown in a reservoir of 1.0 based on the assumption that this would be an unlikely event. For Bear Creek, the safety factor of 1.0 is considered applicable since the flood event is somewhat rare and the presence of a

granular soil existing in significant quantities and prone to complete saturation during a flood event is also unlikely.

Comparison with other Criteria

98. On the Rochester Stage 3 project, somewhat similar channel slope conditions exist. For stage 3, an intermediate river stage analysis was assumed where a constant lag of 4 feet was assumed and the water level in the stream was varied. This determined a factor of safety of 1.3 for a 2H:1V slope and $\phi = 33$ degrees. On Stage 2B, a similar analysis determined a minimum factor of safety of 1.7 for a 3H:1V slope with a lag of 3 feet and friction angle, $\phi = 31$ degrees. Also, the existing river banks are commonly sloped at 2H:1V along portions of Bear Creek, Cascade Creek and the Zumbro River without distress due to slope instability. Most of the existing bridges along these rivers were built with 2H:1V slopes near the underpasses.

PEDESTRIAN PATHS

99. The pavement section for pedestrian paths will consist of 2 inches bituminous wear course (MnDOT 2331, type 41) and 6 inches of aggregate base course (MnDOT 3138, class 5). This pavement section was used on previous stages of the Rochester project. The surficial topsoil and any soft cohesive soils or debris will be stripped where observed in the upper 24 inches of the subgrade, and the subgrade will be surface compacted with a smooth drum roller prior to placement of aggregate base. This section has a granular equivalency of 10.5 inches (where the unit granular equivalencies are 2.25 for MnDOT 2331, type 41 and 1.0 for class 5 aggregate). This exceeds the total granular equivalent of 6 inches for a 7 ton pavement design for granular subgrades (minimum 4 feet depth sand with a Hveem stabilometer value of R=70) as given in the MnDOT Road Design Manual (dated 1/31/82), fig. 7-5.03A. The predominant alluvial sands in the area have an estimated Hveem stabilometer value in the range R=40 to 70*. The MnDOT 7 ton pavement is applicable to light residential traffic.

RIPRAP BEDDING

100. Riprap bedding gradations have been established based on existing bedding gradations produced at the local quarries for previous stages of the Rochester flood control Project and based on filter requirements at the riprap/bedding interface and the soil/bedding interface as given in EM 1110-2-1913, Appendix E. Riprap and bedding to be used on the Bear Creek project are given in Tables C-7, C-8 and C-9. Gradation curves showing requirements for stability of the bedding under riprap types F, G and H are shown in Plates C-8 through C-14.

Piping Potential

101. Gradations for bedding types 1 and 2 generally meet filter criteria for limiting migration of fines from the existing base soils. There are however some base soils that would migrate through the type 1 and 2 beddings. For the type 4 bedding, the filter size is significantly less. The granular soils on the downstream portions of the completed stages have been predominantly medium grained sands. Some of the soils in the Bear Creek area are fine to medium sands. After analysis of the violations of the stability criteria, we

conclude susceptible soils are not located in areas where groundwater hydraulics would induce piping.

102. Based on inspection of the gradation curves (figures 3 - 6), it is our conclusion that the majority of the sands are stable under the type 1 and 2 beddings. The fine grained sands not meeting the stability criteria for the d_{85} grain size of the base soil are approximately identified as material having greater than 80% passing the No. 40 sieve. These particle size analyses have been considered individually.

103. Areas for the downstream portion are listed in Table C-4 for sieve analysis tests where material passing the no. 40 sieve (P_{40}) was greater than 80%.

TABLE C-4 - MATERIALS WITH P40 > 80%

BORING	SOIL TYPE	PASSING #40 SIEVE [%]	DEPTH BELOW GROUND SURFACE [FEET]	DEPTH ABOVE CHANNEL INVERT [FEET]
81-33	SP-SM	98	4.1	7
89-244	SM	81	9.3	6
89-245	SM	88	5.9	7
89-251	SM-SP	94	4.2	11
89-260	SM	98	9.9	N/A
89-266	SC	81	5.7	10
89-267	SM-SP	81	6.6	10

104. In general (in the downstream area and other portions), the soils with P_{40}>80% were typically fill soils near the surface, or native soils directly below the surficial topsoil. Cross sections of the channel are shown in plates C-15 through C-18 for the above borings. These are addressed as follows:

(1) Boring 89-260 (sample at 9.9 feet) was sampled in fill soils in the highway embankment leading to the bridge abutment. These soils will be behind the wing walls and concrete abutment.

(2) At boring 89-244, the right bank area downstream of the 4th Street bridge will include interlocking slope protection with an appropriate filter for the soils in this area.

(3) Borings 89-251, 89-266 and 89-267 identified stratum with fine grained granular soils limited to elevations 10 to 11 feet above the channel invert. This is at the approximate 100 year flood level. Thus, seepage of water through these soils would rarely occur.

(4) Fine grained stratums encountered in borings 89-245 and 81-33 occur about 7 feet above the channel invert, or about at the 10 year flood level. The areas occur near localized high rock areas. The top of rock slopes downward away from the channel and the rock is overlain by typically pervious (SP) sands. It is anticipated that gradients would seldom flow from the overburden in the banks of the river at this location.

STREAM BED EROSION

105. It is not considered economical or aesthetically pleasing to armor the channel in areas where the erosion potential is very low (with a rock surface) or rather low and limited by underlying barrier at shallow depth (with a rock/silt or rock slab surface directly overlying rock). It is the intent of the design to utilize these features where possible. However, some erosion potential exists.

Rock

106. The unlined channel subgrade will consist of sedimentary rock ranging in quality from hard, cemented dolomite to soft, poorly cemented sandstones. Some of the rock is friable and susceptible to slaking and freeze thaw action. The existing channel has eroded the softer rocks that have become exposed and has in some areas formed a hard crust over marginal rocks. Natural erosion of the existing rock stream bed has slowed to an equilibrium rate that is very minimal. For the depths of excavation on this project, there is not a pronounced tendency for the rocks to become harder or less weathered with depth. Re-establishing the channel invert will expose areas of soft/weathered rock that will be more susceptible to erosion than the existing stream bed.

107. Erosion of the weak sandstones will be limited by stratifications of cemented sandstones, limestone and dolomite. Anticipated consequences of the erosion will be some minor sedimentation and undulations in the channel invert. The sediment from this source is not likely to be significant in relation to sediment from upstream sources. Undulations in the channel invert is a more valid concern where it may occur adjacent to retaining walls, drop structures or bridge piers.

6th Street Bridge

108. The 6th Street bridge (Sta. 23+30) is founded on spread footings cast on rock with bearing pressure of 2.16 to 2.25 tsf. The footings are embedded a minimum of 12 inches into the rock. The existing bridge was designed with about 2 feet of cover over the top of footing. Conditions in April 1992 include about 3 to 6 feet of cover over the top of footing due to sedimentation. As-built plans identify pier footing elevations of 980.0 at the bottom and 982.0 at the top. The proposed channel invert is about mid-depth of the footing, varying from 980.8 at the downstream end to 981.1 at the upstream end of the bridge.

109. Scour prevention for the footings will be necessary unless the surficial rock around the footings is erosion resistant. Borings extended for stage 4 near 6th Street did not include rock cores. The City also extended 6 borings (identified on the as-builts) to top of rock during construction of the bridge in 1962. Proposed improvements will include a lined channel upstream that will reduce sedimentation, channel velocities near the bridge in the range of 9.7 to 10.0 fps for the design event, and a partially exposed footing. As such, we recommend scour protection for the two bridge piers unless rock cores are extended that identify a competent limestone or dolomite rock in this area. Scour protection would probably consist of a concrete slab.

Silt and Rock

110. There are also areas of the unlined channel where the subgrade will consist of a stratum of broken rock and silt. We do not consider this stratum to consist of rock. It may be more characteristic of soil or rock, varying with depth and location. The structure of this material may range from cobble to boulder sized, nested slabs of rock with silt filled joints and cavities to coarse gravel sized crushed rock with silt filled pores.

111. The latter material is gap graded and is internally unstable (for susceptibility to piping). Loss of the fine fraction of soil will occur if a gradient promotes seepage through it. Turbulence in the water may also wash the fines out from the upper portion of the rock. The subsurface exploration did not define a particle size distribution for coarse gravel and cobble sized material. However, other reaches of the Rochester project under construction have encountered similar deposits. Based on our anticipation of the material, an armored bed layer should form to limit erosion. The formation of the armored bed is promoted by the underlying rock.

112. The denser material consisting of nested rock slabs will be susceptible to washing of fines from the joints and cavities. Some of the surface rocks will become loosened during excavation and will be more susceptible to erosion than the undisturbed rock. The anticipated shape of the rocks is flat and elongated. Some of the smaller slabs will erode in higher water velocities during periods of flooding. This will eventually result in some variations from the channel invert tolerances established during construction. A channel bed that is constructed flat and uniform may be expected to develop some rough surfaces, similar to the natural channel.

SCOUR PROTECTION ALTERNATIVES

113. Alternative scour protection systems employed in the Bear Creek project include: 1) turf, 2) turf placed over riprap, 3) interlocking slope protection, and 4) allowing limited scour of the low flow channel. Reinforced turf (with erosion control geosynthetics) is an additional alternative that was considered but not incorporated. Reinforced turf will also be discussed due to it's potential to be easily incorporated into the project if needed. Turf refers to specific species of grass that tend to form a dense, intertwined root mat. Interlocking slope protection refers to concrete blocks or fired clay bricks that form a pavement. Interlocking slope protection is referred to by some references as "articulating block systems."

COST ESTIMATES FOR BEAR CREEK

114. A chart showing cost estimates vs. approximate flow velocities for general categories of erosion control systems is attached. Cost estimates are for installed prices that include cost of excavating to the required excavation depth to install the liner, and any necessary provisions such as geotextiles, bedding for filter criteria and labor. Costs shown in the figure are December 1991 estimates for the Rochester area, and should not be used as the basis for cost estimates on any other projects.

115. Turf and reinforced turf are the cheapest form of scour protection, but are not effective for higher velocities. Interlocking slope protection is a high cost alternative which is effective for high velocities, similiar to riprap. On Bear Creek, a combination of low cost alternatives combined with interlocking slope protection has been incorporated to enhance recreational facilities and to provide a more natural appearance at the same approximate base cost as the full riprap lined channel proposed in the GDM.

Maintenance

116. Maintenance for riprap slope protection routinely consists of spraying herbicides to keep brush and weeds down. Another maintenance item has included replacement in areas where people have thrown the rocks in the water. For this reason, 18-inch riprap has been used in public areas, such as parks, fishing areas, and areas in the city.

117. The most significant maintenance problem (high costs at unexpected times) would likely be sod placed over riprap which is expected to fail in a design (170 year flood) event. This would require topsoil and sod replacement and possible dredging of siltation downstream following a flood.

118. For turf systems (including grass over riprap, interlocking slope protection and turf reinforcement), the areas could either be maintained with mowed grass or left as tall grass. These systems could be maintained similar to a highway right of way or park areas.

119. Non-reinforced turf, due to its low cost, could either be designed to be stable for the design event or could be designed to fail at periodic intervals and be replaced. If the system were designed to meet less than the design flood, the maintenance factor could become the most significant cost concern.

120. Vandalism is a concern in the urban areas based on downstream stages. For interlocking slope protection, the blocks are very difficult to pry loose once vegetation has been established. Removal of the blocks would require tools to excavate the sod and topsoil. Cable tied systems and attached geotextiles would also prevent the blocks from being removed. Cables and geotextiles are also less a target for vandalism if the turf is maintained since the components will be less visible. Turf reinforcement systems likewise should not be visible.

121. Another concern is potential damage to downstream structures from loose mats of geosynthetics (for turf reinforcement and riprap surface treatment). If these products did fail extensively, the mats could become entangled upon bridges and dams, causing or contributing to debris jams.

DESIGN METHODOLOGY

Permissible Velocities

122. Design methodology for alternative scour protection systems is not well developed. The design of riprap has been studied extensively and the evaluation is specific as a function of water velocity, channel side slopes and turbulence. The sizing of the riprap is commonly a function of the shear

stress on the bed, since the shear stress can be evaluated based on the hydraulics independent of the lining system. For most alternative revetment systems, the sizing of blocks or mats is based on empirical charts derived from scale model studies. In most cases, the critical shear stress is not given as the design procedure and sometimes the design criteria is based on incomplete models that are a function of discharge quantities, craftsmanship, potential for damage, erosion potential of underlying soil, quality of cover soil & void filler, maintenance commitments, duration of the flood, and variations in the vegetation quality (winter dormancy, drought conditions, etc.) The interlocking slope protection is designed at or near the critical failure condition observed in model studies, with the assumption that the field installation will include filled voids that were not filled in the model tests. Tests have shown that the articulating blocks can withstand about double the velocity if the voids are filled (ref. p.185, Simons, Li & Assoc.).

123. In assessing the permissible velocity of a turf lining, a relationship was derived based on methods found in the U. S. Department of Agriculture manual, "Stability Design of Grass Lined Open Channels." This relation is shown graphically in plate C-19, which is plotted using criteria contained in EM 1110-2-1601, plate 28. The permissible velocities are plotted as a function of the D_{75} grain size for non-cohesive soils. The criteria is in agreement with other references. Plate 28 of EM 1110-2-1601 identifies permissible velocities for typical sands at Bear Creek to be in the range of 2 fps. Fine sand to coarse silt is the most erodible soil type. NAVFAC DM 7.1-300 lists permissible velocity of 1.5 fps for bare channels in sand and 2 to 4 fps with vegetation. For non-reinforced turf placed on these soils, a permissible velocity of about 4 fps is indicated for a cover factor of about 0.75. This cover factor is applicable to mixed grasses. Higher permissible velocities could be obtained by using reinforcement, lean cohesive topsoil, higher maintenance of the grass species, or possibly by blending gravel in the topsoil.

124. A preliminary assessment (of allowable vegetal stresses and feasible expectations of the dimensionless cover factor (C_f) based on available grass species that can be established in the project and maintenance considerations) was made based on methods in the USDA manual. Definition of the cover factor and typical values for some species of vegetation are included in the USDA manual. A relationship is given in the CIRIA report regarding the effect of reinforcement incorporated in turf and flow duration on permissible velocities.

Uplift Potential

125. For somewhat homogeneous cohesive or semi-cohesive soils, uplift is unlikely for most revetment systems. Most interlocking slope protection systems have provisions (optional for some) for percolation of seepage. The weep holes or open voids area in the revetments allow water to pass through the matrix used to fill the voids. At Bear Creek, the predominant soils consist of sands with an estimated permeability in the range of 0.1 to 0.3 fpm. If these sands were to become saturated in the vadose zone during a design event, the seepage quantities along the channel embankments could be significant (although for a short period of time).

126. For riprap, uplift is unconditionally satisfied for any gradient of groundwater migration out of the channel banks since the permeability is higher near the surface than in the base soil. For interlocking slope protection, the voids can be either filled with open graded aggregate to allow rapid percolation of water, or topsoil to support turf in the voids. If aggregate such as pea gravel is used to fill the voids, the potential for erosion of the void filler is high. If topsoil is used to fill the voids, turf will reinforce the soil and will provide a high resistance to erosion. To maintain strong turf, a rich topsoil is desired that will retain moisture for resistance to drought. For granular sites, the need to provide an organic material which will sustain vegetation growth and allows seepage for any gradient results in contradictory criteria that can not both be met. On Bear Creek, we are proposing topsoil placed over riprap only on the benches and high-flow slopes. The interlocking slope protection will be filled with a pervious material near the toe and filled with topsoil and seed near the crest.

Bedding for Interlocking Slope Protection

127. The interlocking slope protection will be laid on a non-woven geotextile placed directly on the native soils or random fill. Manufacturer's of interlocking slope protection strongly recommend a geotextile directly on the base of the blocks. Substitution of a graded filter rock is not recommended to replace the geotextile, although it could be an addition. This is because scour can erode the matrix in the voids between blocks (usually consisting of seeded topsoil, pea-gravel or aggregate). The blocks are very sensitive to minor erosion of subgrade near the base. Any small voids near the base of the blocks will allow the blocks to tilt easier. If the blocks tilt, the hydraulic drag increases dramatically which can lead to failure.

Effect of Ice

128. Ice sheets have the potential to bond to articulating blocks and pull pieces from the revetment system. Interlocking slope protection is a system that can lose integrity if damaged. The report by Simons, Li & Associates, "Minimizing Embankment Damage During Overtopping Flow" discusses how loss of contact at any block in the system may lead to rapid destabilization, characterized by local scour and/or uplift which can then propagate through the system. Riprap is not as sensitive to destabilization since the material lies loose and does not need to be structurally joined and oriented to be effective. It only needs to be uniformly distributed. Moving ice sheets can cause riprap to become displaced and dispersed at levels near the normal water surface and in some extreme cases may carry the rocks leaving exposed soil. However, with interlocking slope protection, the blocks only need to be cracked, broken or separated to become weakened. Rips in the geotextile could also destroy the effectiveness of the system. We are aware of several projects where interlocking slope protection has been reported to be resistant to ice damage. It is considered very improbable that significant ice damage would occur on Bear Creek. However, it has been intended to avoid interlocking slope protection at the normal water level where possible. Turf and reinforced turf will not be installed near the normal water levels and thus should not be effected by ice sheets.

PROVISIONS INCORPORATED IN BEAR CREEK

129. Turf placed over riprap is the most cost effective solution for establishing a useable surface for recreation and vissual screening while providing a conservative erosion barrier in congested areas where bank scour can not be tolerated. This alternative is used above the 20 year flood elevation, from Stations 0+00 to 40+00. It is also used on the benches and high flow channel banks on the outside of channel bends.

130. Interlocking slope protection is used in the low-flow channels through Slatterly park and at the Zumbro river confluence (where interlocking slope protection was placed as part of stage 1B-3). These two locations are recreational areas where access to the channel is important. At these areas, interlocking slope protection is the most desireable alternative since it combines features of resistance to frequent flooding, high velocities and a desireable surface.

131. A riprap berm will be placed at the low-flow bank toe through Slatterly park where the interlocking slope protection meets the normal water level. The riprap berm serves as: 1) uplift protection, 2) an aid to constructibility since it may reduce dewatering needs, 3) higher resistance to ice damage.

132. Plain (unreinforced) turf will be placed on the benches and high flow channel banks on straight channel sections and on the inside of bends through Slatterly park. The velocities for the design event are low enough to fall within the limits of turf erosion protection. Also, bank erosion (an unlikely and unexpected, but possible occurrence) in this area would not create a safety concern or loss of property. Use of turf erosion protection was made feasible by increasing the low flow channel width and raising the bench height so that high flow bank flooding is less frequent and velocities are lower than those in the GDM.

133. The feature of eliminating the channel lining on the low-flow channel bottom through Slatterly park is considered to be a pragmatic transition between the unimproved channel upstream of Station 71+60 and the lined channel downstream of about Station 47+00. Sedimentation carried downstream from this unlined portion of the channel is estimated to be insignificant in relation to sediment from upstream sources. The inland channel bottom is desireable for fish habitat through Slatterly Park. The low-flow bank protection is extended below the channel invert as shown on method A, plate B-43 in EM 1110-2-1601.

CONSTRUCTION CONSIDERATIONS

ROCK REMOVAL PLAN

134. Bedrock excavation will be required in channel reaches from approximately Stations 12+00 to 16+00 and from approximately Stations 24+00 to 50+00. Bedrock could be encountered outside these limits as well. Based on observations made of rock outcrops along the Zumbro River, as well as

during the construction of Stage 1B-3, the following determinations have been developed and described in the following paragraphs. Excavation procedures required will likely be a combination of mechanical methods and blasting.

EXCAVATION METHODS

Ripping

135. Experience from similar rock excavation in Stage 1B-3 construction has been considered. Production rates were very slow using a CAT 245 backhoe. A CAT D-8 dozer with a hydraulic ripper was marginally successful where the ripper could reach a weak seam in the rock, but unsuccessful where the ripper could not reach a weak layer. This upper rock had a high frequency of fractures, although they were typically tight and not always interconnected. A similar sequence of interbedded dolomite and sandstone rock occurs in this reach; therefore rock excavation is expected to be similar.

136. The overburden/bedrock interface is gradual and characterized by a highly fractured zone with soil filled joints and cavities. In some areas the transition may occur over a thickness of 3+ feet and in other areas it is more abrupt. To correlate geologic stratums with excavation methods, it has been the intention to define the "top of rock" indicated on the boring logs as that interface where rock excavation will be required. The material identified as "rock" in the boring logs has been based on the visual observations of rock cores, the rock outcrops observed in the river channel, and excavation effort observed in Stage 1B-3 construction. However, excavation methods can influence the degree to which the material can be removed. Other factors that may influence the top of rock elevations observed in the field compared with those reported in the borings include variations in the stratigraphy, roughness of the interface near the borehole, and judgement as to the rock strength.

137. Blasting or rock removal methods other than ripping are considered necessary for construction of this reach. Sculpturing the rock to close tolerances will require special treatment such as line drilling, lightly loaded smooth blasting or specialized mechanical excavation.

Blasting Characteristics

138. Rock cuts will most likely require loosening by blasting. The response of rock in the Rochester area to blasting is typically good and results in good rock breakage. To control airblast and flyrock, blast patterns and charges may require modifications on a routine basis to accommodate soft layers and variations in the stratigraphy. Blasting in Stage 1B-3 was successful and was apparently cost effective. Stage 4 will require more restriction and precautions than Stage 1B-3 due to the close proximity to structures. Achieving these goals will require site calibration to determine the charge weights and delay patterns, preconstruction inspection of structures, education of the public, rigidly enforced rules for the conduct of the blasting, and vibration and air-blast monitoring. The thin-bedded and fractured nature of the rock makes it necessary to take special precautions to prevent overbreak at the tops of the blast holes.

Other Excavation Methods

139. Although the costs, as well as the contractors preference for certain equipment will likely make blasting the most attractive option for the majority for the rock removal, other methods may be employed for some areas. Such areas may include low free face areas, footing excavation, near existing structures, and localized outcrops encountered after blast crew demobilization. The thinly bedded structure of the bedrock and the abundant fractures in this rock make it conducive for mechanical breakage. Although the construction contractor for Stage 1B-3 has shown slow production rates with a CAT 245 and D-8, other mechanical means such as a large hoe-ram on a hydraulic excavator or an impact ripper on a D-8 or D-9 would be more productive. The construction contractors in Stages 1B-3 and 2B have had good success using an intermediate sized hoe ram in areas near existing structures, which require more delicate removal of rock, and areas with lesser quantities of rock removal.

Rock Excavation Close to Existing Structures

140. The proposed project is close to businesses, bridges, apartment buildings, and single-family residences. As a result, ground vibrations generated by blasting (or other construction activity) must be controlled and monitored to prevent damage to adjacent structures. Blasting criteria as provided in EM 1110-2-3800 will be used in specifying requirements.

141. Rock excavation close to existing structures must be conducted in such a manner that will not endanger the foundation. Permanent rock slopes or cuts will be setback from structures such that erosion will not undermine the slope and cause distress to the structure. Temporary slopes may require stabilization to limit lateral movement of nearby structures founded on spread footings.

Character of Excavated Rock

142. Rock excavated for widening and deepening the stream channels is expected to be slabby and have an average thickness of less than 8 inches. This thin, slabby character will limit its use on the project without additional processing. If the rock were crushed, it may be suitable for use as granular fill. However, it would likely not meet MnDOT durability standards for aggregate due to weak, poorly cemented layers in the rock. Also, shale layers exhibit poor freeze-thaw performance, which also limits usage of the rock.

GAS MAIN

143. There is an existing 10 inch diameter gas main that runs along 10th avenue SE and crosses the existing channel at approximate stations 34+00 to 37+00. If the gas main retains the same alignment, it will cross the proposed channel at approximate stations 36+00 to 39+00. This gas main is the largest of 3 gas lines that are proposed to be moved as part of the Stage 4 project.

144. Safety of blasting near the pipe is a concern. From verbal discussions with Peoples Natural Gas (owner and operator of the pipeline), we understand the line contains natural gas at a standard operating pressure of 72 psi and is embedded in rock where it crosses the existing channel. The overburden is

shallow NE of the crossing, so the pipeline is likely laid close to rock for a considerable distance from the crossing. The pipeline separation from the rock will affect the vibration intensity transmitted to the pipe during blasting since the attenuation of the rock is lower than overburden.

145. We understand the pipeline can be shutdown during the summer when the demand for gas is low. Coordination with the Gas Company may be possible to shut the pipeline down during most or all of the blasting work. If time constraints require some blasting while the pipeline is operating, a vibration limit will be established for monitoring the peak particle velocities of the pipe or exposed rock.

TEMPORARY EXCAVATION CONSIDERATIONS

146. Slopes as steep as 1.5H on 1V are expected to remain stable for temporary construction excavations in the fine sand soils above the water table. However, lateral movement has the potential to effect structures founded on spread footings or slabs/pavements near such slopes. The preconstruction survey conducted in conjunction with the blasting program should address these structures. The use of tied-back or cantilever sheet-pile walls or other type of temporary construction shoring may be required in areas where open excavations would encroach on existing streets or structures.

CARE OF WATER AND CONSTRUCTION DEWATERING

147. Care of water will be required during construction. Dewatering of the foundation soils and rock will be required for construction of the drop structures and some of the retaining walls. Dewatering may also be required for some of the channel excavation. Dewatering will probably consist of shallow well points, aggregate French drains along soil/rock interfaces, and deep wells into soil or possibly complemented with deep wells into rock as required. The outboard slopes of cofferdams will require temporary erosion protection.

148. Care of water for channel excavation will probably consist of cofferdams constructed of earthen berms augmented with drains and sump pumps. The water table along the project alignment is the same as the water levels of the river. Therefore, as the channels are deepened, drainage of the surrounding ground water must be sufficiently slow to prevent piping or sloughing of sands. Normally, drainage will occur naturally as excavation progresses and no problems are anticipated. In some areas where excavation exceeds channel depth, temporary dewatering with shallow wells may be required. We anticipate the Contractors awareness of the potential for piping or sloughing of the soil banks will be substantiated during construction submittals for dewatering plans. Excavation or pumping rates can be slowed if imminent dewatering and drainage problems appear.

149. The downstream drop structure and retaining walls founded on rock will be constructed with a 6 to 12 inch layer of drainage fill material placed on the rock. The drainage layer will act as a porous mattress so that there is not standing or running water on the surface during placement of concrete for slabs and foundations. The seepage water should flow through the drainage

layer to a sump, drain tile, or well points. Based on construction experience from Stages 1B-3 and 2B, the groundwater flow through the fractured bedrock/overburden interface can be significant. Over-excavating the rock and placing structures on a pervious base will facilitate dewatering by sumping in the rock excavation areas.

SOURCE OF CONSTRUCTION MATERIALS

150. Granular materials required for the project include random fill, pervious fill, semi-pervious fill, riprap, riprap bedding, coarse drainage aggregate, aggregate base course for pavements and concrete aggregate. Random fill and semi-pervious fill can be obtained from on-site excavations. The remaining materials will need to be imported from off-site sources. The availability of adequate resources has been identified. Materials from potential sources have been used recently and exhibited suitable performance.

SEMI-PERVIOUS FILL FOR RETAINING WALLS

151. The semi-pervious fill placed behind the retaining walls will consist of a granular material with a maximum of 10 percent fines. On the basis of laboratory sieve analyses, a large percentage of the alluvial material excavated during widening of the channel may be used as semi-pervious fill.

GRANULAR MATERIALS AND AGGREGATES

152. Granular materials are not abundant in the Rochester area but are available. Pervious sand and fine aggregate for concrete may be found in river basins and is available from producing pits in the valleys of the South Fork Zumbro River and Cascade Creek. Producing pits are less than 2 miles from the city.

153. Coarse aggregate is not readily available naturally, and is manufactured from quarries. Riprap, bedding, and drainage fill for completed phases of the Rochester flood control project has been produced from quarries in the Shakopee and Oneota Formations. The closest operating quarries with acceptable materials are the Hammond 1, Hammond 2, and Goldberg Quarries, located 6 to 16 miles north of the city. These quarries have been used extensively by the Minnesota Department of Transportation and have been used on previous stages of construction of the Rochester flood control project. Rock from the Oneota Formation, which outcrops north of town, has supplied good riprap for completed stages on the Zumbro River. Rock quarries in Rochester and south and west of town have not been approved for slope protection sources because they are less resistant to freeze-thaw.

DISPOSAL AREAS

154. Excavated material that is deemed unsuitable for use on the project will be disposed at predetermined locations. Two potential disposal sites that have been identified at this time include up to about 300,000 cy at a residential subdivision at Viola Dr. and Circle Drive, and up to about 75,000 cy at a residential subdivision at Silver Creek Road and Circle Drive. A Soil

Conservation Service dam site could also be used for a large quantity of fill, but this is a longer haul distance and likely will not be used.

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TABLE C-5

BORING SUMMARY
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - BEAR CREEK
ROCHESTER, MINNESOTA
STAGE 4

Boring	Boring Number	Approximate Channel Station	Approximate Distance and Direction From Proposed Center-Line (ft) L-Left, R-Right	Ground Surface Elevation 1929 NGVD	Depth to Bedrock (ft)	Bedrock Elevation	Bottom of Hole Elevation
1	81-32M	3+10	2'L	983.4	31.6	951.8	--
2	89-244M	6+00	94'R	988.6	26.0	962.6	--
3	81-31M	7+10	72'L	990.0	45.0	945.0	--
4	90-282M	9+50	25'R	986.3	21.6	964.7	--
5	89-265A	9+90	0'	987.6	15.5	972.1	--
6	89-251M	10+10	25'L	987.7	23.0	964.7	--
7	90-281M	12+10	62'L	994.3	20.9	973.4	--
8	91-295M	13+00	58'L	995.7	13.2	982.5	--
9	92-296M	13+20	67'R	991.5	10.0	981.5	--
10	89-264M	14+10	66'R	992.4	10.3	982.1	--
11	89-252M	14+70	59'L	995.9	12.1	983.8	--
12	81-36M	18+20	93'R	986.0	3.6	982.4	--
13	89-245M	18+30	74'L	994.6	17.0	977.6	--
14	89-270M	21+90	45'L	996.6	19.6	977.0	--
15	89-271M	23+20	61'R	966.0	12.5	983.5	--
16	89-266M	24+10	69'L	998.6	14.1	984.5	--
17	89-267M	24+80	81'L	1001.4	12.4	986.0	--
18	89-246M	28+00	33'R	999.3	8.7	990.6	--
19	81-33M	30+60	75'R	996.4	5.7	990.7	--
20	89-268M	32+90	10'R	1002.6	10.9	991.7	--
21	89-269M	35+50	90'R	994.8	4.4	990.4	--
22	89-262M	36+90	10'L	997.5	6.9	990.6	--
23	89-263M	40+00	110'R	1003.2	13.3	989.9	--
24	81-35M	48+00	50'L	998.0	12.1	985.9	--
25	89-261M	51+10	45'R	998.9	14.7	984.2	--
26	81-34M	60+10	60'L	1000.9	25.0	975.9	--
27	89-259M	62+30	146'L	1008.2	26.7	981.5	--
28	89-260M	62+30	148'R	1006.0	30.0	976.0	--
29	89-248M	66+60	32'R	1000.8	20.9	979.9	--
30	89-247M	66+70	70'L	1002.1	25.2	976.9	--

BORING SUMMARY
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - BEAR CREEK
ROCHESTER, MINNESOTA
STAGE 4

TABLE C-5

Boring	Boring Number	Approximate Channel Station	Approximate Distance and Direction From Proposed Center-Line (ft) L-Left, R-Right	Ground Surface Elevation 1929 NGVD	Depth to Bedrock (ft)	Bedrock Elevation	Bottom of Hole Elevation
31	81-37M	67+10	63'R	999.5	N.D.	N.D.	944.5
32	89-256M	67+40	194'R	1001.3	N.D.	N.D.	961.3
33	89-254M	68+60	15'R	1002.5	N.D.	N.D.	962.5
34	89-255M	69+70	5'L	1003.0	N.D.	N.D.	963.0
35	89-249M	69+70	252'L	1001.6	31.9	969.7	--
36	81-40M	72+60	464'R	1002.5	47.4	955.1	--
37	89-276M	73+10	90'L	1002.5	N.D.	N.D.	962.5
38	89-275M	73+50	84'R	1001.1	45.0	956.1	--

NOTES:
1. Distances left (L) or right (R) of centerline are as viewed looking downstream.
2. Channel stationing is rounded to nearest 10 feet.
3. Two or three feet thickness of weathered rock and/or rock slabs is common above the refusal elevations.

TABLE C-5

BORING SUMMARY
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - BEAR CREEK
ROCHESTER, MINNESOTA
STAGE 4

Boring	Boring Number	Approximate Levee Station	Approximate Distance and Direction From Proposed Center-Line (ft) L-Left, R-Right	Ground Surface Elevation 1929 NGVD	Depth to Bedrock (ft)	Bedrock Elevation	Bottom of Hole Elevation
1	89-250M	7+20	15'R	1002.1	25.7	976.4	--
2	89-253M	14+40	80'R	1003.9	32.0	971.9	--
3	81-38M	15+90	20'L	1004.8	25.7	976.4	--
4	89-258M	18+90	33'R	1006.2	25.8	980.4	--

NOTES:
1. Distances left (L) or right (R) of centerline are as viewed looking downstream.
2. Levee stationing is rounded to nearest 10 feet.
3. Two or three feet thickness of weathered rock and/or rock slabs is common above the refusal elevations.
4. Borings: 89-250M, 89-253M, 81-83M, and 89-258M, are located according to levee stationing, rather then channel stationing.

TABLE C-6

BEDROCK PROBE SUMMARY
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - BEAR CREEK
ROCHESTER, MINNESOTA
STAGE 4

Probe	Approximate Channel Station	Approximate Distance and Direction From Proposed Center-Line (ft) L-Left, R-Right	Ground Surface Elevation 1929 NGVD	Depth of Refusal (ft)	Refusal Elevation
1	6+90	112'R	990.5	26.3	964.2
2	8+60	72'L	988.4	46.9	941.5
3	8+60	43'R	987.5	33.1	954.4
4	9+60	28'L	987.0	32.9	954.1
5	12+10	96'L	993.6	23.5	970.1
6	12+90	67'L	995.4	14.6	980.8
7	12+90	117'L	994.8	19.8	975.0
8	21+50	44'R	993.4	11.4	982.0
9	30+90	45'R	999.7	8.9	990.8
10	33+80	115'R	1002.5	11.7	990.8
11	33+80	22'L	996.1	5.2	990.9
12	36+80	85'R	994.3	4.5	989.8
13	39+50	17'L	997.7	8.5	989.2
14	39+50	52'L	999.9	10.2	989.7
15	41+30	35'L	997.0	8.0	989.0
16	41+30	69'L	998.1	8.7	989.4
17	41+50	68'R	998.3	9.0	989.3
18	43+30	75'R	998.7	9.8	988.9
19	43+30	32'R	995.7	6.6	989.1
20	43+50	42'L	995.6	7.5	988.1
21	43+50	78'L	998.3	8.9	989.4
22	45+10	43'R	998.4	11.7	986.7
23	45+10	69'R	998.4	9.6	988.8
24	45+60	67'L	990.0	1.6	988.4
25	45+70	37'L	997.1	10.2	986.9
26	48+70	113'R	999.8	14.8	985.0
27	48+90	67'R	997.9	13.5	984.4
28	48+90	72'L	999.2	13.5	985.7
29	48+90	28'L	997.8	12.3	985.5

TABLE C-6

BEDROCK PROBE SUMMARY
DESIGN MEMORANDUM NO. 6
FLOOD CONTROL - BEAR CREEK
ROCHESTER, MINNESOTA
STAGE 4

Probe	Approximate Channel Station	Approximate Distance and Direction From Proposed Center-Line (ft) L-Left, R-Right	Ground Surface Elevation 1929 NGVD	Depth of Refusal (ft)	Refusal Elevation
30	50+30	55'L	1001.9	20.4	981.5
31	51+30	23'L	997.5	15.5	982.0
32	51+40	65'L	1000.0	18.6	981.4
33	51+40	60'R	998.2	14.0	984.2
34	53+10	60'R	999.6	15.0	984.6
35	53+20	40'L	1000.8	15.5	985.3
36	53+30	75'L	999.7	14.5	985.2
37	53+90	75'R	998.8	14.9	983.9
38	55+10	103'R	1000.7	16.3	984.4
39	55+20	16'L	995.9	12.8	983.1
40	55+20	52'L	1001.2	18.9	982.3
41	55+20	73'R	1000.3	18.7	981.6
42	56+70	58'L	1001.0	18.4	982.6
43	56+70	30'L	996.4	11.8	984.6
44	56+80	68'R	1000.3	21.2	979.1
45	58+50	118'R	1002.5	23.1	979.4
46	58+50	76'R	1001.5	22.7	978.8
47	58+60	0'	998.0	17.5	980.5
48	58+70	50'L	1001.3	21.6	979.7
49	60+80	142'R	1001.3	21.7	979.4
50	61+50	100'L	1004.4	26.1	978.3
51	62+90	80'R	1003.6	29.7	973.9
52	63+40	83'L	1002.7	22.7	980.0

NOTES:
1. Distances left (L) or right (R) of centerline are as viewed looking downstream.
2. Channel stationing is rounded to nearest 10 feet.
3. Refusal elevations are inferred as top of firm bedrock for design and estimation purposes.
4. Two or three feet thickness of weathered rock and/or rock slabs is common above the refusal elevations.

TABLE C-7
RIPRAP GRADATIONS BY WEIGHT (165 LBS/FT^3)

ETL 1110-2-120 DESIGNATION	STAGE 4 GRADATION	W_{100} MAX	W_{100} MIN	W_{50} MAX	W_{50} MIN	W_{15} MAX	W_{15} MIN
LA	A	86	35	26	17	13	5
LC	B	292	117	86	58	43	18
HG	C	400	160	169	80	84	25
LE	D	691	276	205	138	102	43
LF	F	984	394	292	197	146	62
LI	G	2331	933	691	467	346	146
HJ	H	1098	439	463	220	232	69

TABLE C-8
REQUIRED BEDDING THICKNESS (IN INCHES) AND RIPRAP TYPES

STAGE 4	PRIMARY BEDDING		SECONDARY BEDDING	
GRADATION	TYPE	THICKNESS	TYPE	THICKNESS
A	4	6	NONE	
B	1	9	NONE	
C	2	12	NONE	
D	2	12	NONE	
F	2	12	NONE	
G	A*	12	4	6
H	A*	12	4	6

NOTE: *Type A is riprap gradation

TABLE C-9
BEDDING GRADATIONS

TYPE 1

SIEVE NO.	PERCENTAGE PASSING BY WEIGHT
6"	100
3"	76 - 100
2"	63 - 100
1-1/2"	57 - 81
3/4"	38 - 61
3/8"	23 - 46
# 4	10 - 33
#10	0 - 17
#20	0 - 7
#40	0 - 3

TYPE 2

SIEVE NO.	PERCENTAGE PASSING BY WEIGHT
6"	83 - 100
3"	63 - 100
2"	51 - 82
1-1/2"	44 - 74
3/4"	28 - 54
3/8"	13 - 38
# 4	10 - 25
#10	0 - 10
#20	0 - 1

TYPE 3

SIEVE NO.	PERCENTAGE PASSING BY WEIGHT
4"	100
3"	91 - 100
2"	79 - 82
1-1/2"	72 - 93
3/4"	53 - 73
3/8"	37 - 56
# 4	23 - 40
#10	10 - 25
#20	0 - 15
#40	0 - 9
#80	0 - 3

SOIL CLASSIFICATION RECORD SHEET

PROJECT: ROCHESTER FLOOD CONTROL, BEAR CREEK	BORING: 89-244 thru 89-252	MRD LAB NO. 90/280
STATION: RANGE: SURF.ELEV.:	DEPTH TO WATER TABLE:	BO'

TABLE C-10

SAMP NO.	DEPTH TO BOTTOM OF SAMP.	MOISTURE (%)	PLASTICITY (ATT. LIMITS) LL	PI	HYD. ANALYSIS FINES .005	.02mm	GRADING (CUMULATIVE PERCENTS FINER) U.S. STANDARD SIEVE SIZE 200	SANDS 80	40	20	10	4	GRAVEL 3/8	3/4	1-1/2	3 IN	GRADATION CURVE ANALYSIS D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc	CLASSIFICATION TECH MEMO 3-357, MAY 67	REMARKS	PL
Hole	89-244																							
2	4.1						17	23	44	57	65	71	87	100								Silty gravelly sand SM	Note (a)	
3	9.3						19	28	81	97	99	100										Silty sand SM	Note (b)	
4	11.9						3	7	71	88	92	93	94	100			0.36	0.25	0.18	2.03	0.95	Sand SP	Note (c)	
Hole	89-245																							
2	5.9						16	29	88	97	98	99	100									Silty sand SM	Note (d)	
Hole	89-246																							
2	7.0		24	12			31	41	61	75	81	85	90	90	100							Gravelly clayey Sand SC	Note (e)	12
Hole	89-247																							
4	9.4						0	1	37	90	99	100					0.56	0.37	0.24	2.31	1.02	Sand SP	Note (f)	
6	19.0						10	39	94	99	100						0.24	0.14	0.07	3.47	1.19	Silty sand SM-SP	Note (g)	
8	24.3		24	7			54	65	72	74	75	76	76	76	100							Sandy grav. clay CL-ML	Note (h)	17
Hole	89-248																							
2	9.5						3	7	36	56	69	78	89	92	100		1.02	0.35	0.20	5.20	0.62	Gravelly sand SP	Note (i)	
4	16.7						11	45	95	100							0.22	0.12	0.07	3.11	0.93	Silty sand SM-SP	Note (j)	
5	24.0						6	17	64	91	97	99	99	100			0.39	0.23	0.12	3.23	1.12	Silty sand SM-SP	Note (k)	
Hole	89-249																							
2	4.8						1	7	90	100							0.31	0.23	0.18	1.66	0.92	Sand SP	Note (l)	
3	8.9						7	34	92	99	100						0.26	0.16	0.08	3.04	1.20	Silty sand SM-SP	Note (m)	
7	21.9						10	32	85	98	100						0.28	0.17	1.45	0.19	0.07	Silty sand SM-SP	Note (n)	
8	25.5		27	17			60	84	98	100												Sandy clay CL	Note (o)	10
Hole	89-250																							
2	4.2						3	12	93	100							0.29	0.22	0.17	1.71	0.98	Sand SP	Note (p)	
4	14.5						23	35	82	97	99	100										Silty sand SM	Note (q)	
7	25.0						30	41	45	47	48	53	67	71	100							Silty sandy gravel GM	Note (r)	
Hole	89-251																							
2	4.2						12	30	94	100							0.26	0.18	0.05	5.20	2.49	Silty sand SM-SP	Note (s)	
4	10.9						10	14	21	27	32	42	57	69	69	100	10.84	1.43	0.08	135.49	2.36	Silty sandy gravel GM	Note (t)	
Hole	89-252																							
4	10.5						7	16	79	95	97	98	99	100			0.32	0.22	0.14	2.32	1.08	Silty sand SM-SP	Note (u)	

SOIL CLASSIFICATION RECORD SHEET

PROJECT: ROCHESTER FLOOD CONTROL, BEAR CREEK | BORING: 89-253 thru 89-260 | MRD LAB NO. 90/280

STATION: | RANGE: | SURF.ELEV.: | DEPTH TO WATER TABLE:

TABLE C-10

SAMP NO.	DEPTH TO BOTTOM OF SAMP	MOISTURE (%)	PLASTICITY (ATT. LIMITS) LL	PI	HYD. ANALYSIS FINES .005	.02mm	U.S. STANDARD SIEVE SIZE 200	SANDS 80	40	20	10	4	GRAVEL 3/8	3/4	1-1/2	3 IN	GRADATION CURVE ANALYSIS D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc	CLASSIFICATION TECH MEMO 3-357, MAY 67		REMARKS	PL
Hole	89-253																								
3	7.1						2	4	46	76	86	89	93	95	100		0.56	0.31	0.21	2.67	0.82	Sand	SP	Note (v)	
5	14.9						31	55	81	94	98	100										Silty sand	SM	Note (w)	
7	21.3						21	37	73	84	93	95	99	100								Silty sand	SM	Note (x)	
Hole	89-254																								
3	5.0						6	17	95	100							0.28	0.21	0.14	2.00	1.13	Silty sand	SM-SP	Note (y)	
6	14.5						3	9	48	81	96	98	99	100			0.53	0.30	0.18	2.94	0.94	Sand	SP	Note (z)	
8	24.0						4	12	66	89	97	99	100				0.38	0.24	0.16	2.38	0.95	Sand	SP	Note (aa)	
10	33.2						6	17	63	84	92	95	99	100			0.40	0.23	0.12	3.33	1.10	Silty sand	SM-SP	Note (bb)	
11	35.2		22	6			74	87	98	100												Sandy clay	CL-ML	Note (cc)	16
Hole	89-255																								
6	14.0						3	9	38	75	92	97	99	100			0.62	0.35	0.18	3.44	1.10	Sand	SP	Note (dd)	
8	24.0							4	10	67	95	99	100				0.38	0.24	0.17	2.24	0.89	Sand	SP	Note (ee)	
10	34.0						8	19	75	93	96	97	99	100			0.33	0.21	0.11	3.00	1.21	Silty sand	SM-SP	Note (ff)	
11	35.6						22	43	85	95	97	98	100									Silty sand	SM	Note (gg)	
Hole	89-256																								
3	6.5						2	3	40	91	99	100					0.55	0.36	0.23	2.39	1.02	Sand	SP	Note (hh)	
5	19.0						4	11	71	92	97	99	99	100			0.36	0.24	0.17	2.12	0.94	Sand	SP	Note (ii)	
7	27.1						6	14	53	74	82	85	90	94	100		0.51	0.26	0.14	3.64	0.95	Silty grav. sand	SM-SP	Note (jj)	
9	39.0						4	10	65	87	91	93	94	96	100		0.39	0.25	0.17	2.29	0.94	Sand	SP	Note (kk)	
Hole	89-257																								
2	6.9						11	15	41	66	78	82	91	98	100		0.70	0.31	0.05	14.00	2.75	Silty grav. sand	SM-SW	Note (ll)	
3	10.9						10	13	25	57	73	76	81	81	100		0.93	0.47	0.09	10.33	2.64	Silty grav. sand	SM-SW	Note (mm)	
Hole	89-258																								
2	1.9						19	33	98	100												Silty sand	SM	Note (nn)	
5	11.7						3	16	68	90	97	98	100				0.37	0.23	0.14	2.64	1.02	Sand	SP	Note (oo)	
7	19.4						14	21	55	72	87	93	97	100								Silty sand	SM	Note (pp)	
Hole	89-259																								
2	2.1						13	23	83	94	97	98	99	100								Silty sand	SM	Note (qq)	
7	21.6		16	6			61	72	86	91	93	95	97	100								Sandy clay	CL-ML	Note (rr)	10
8	24.9		NP	NP			30	47	55	57	62	73	78	94	100							Gravelly silty sand	SM	Note (ss)	
Hole	89-260																								
3	6.7						28	33	64	85	90	92	93	94	100							Silty sand	SM	Note (tt)	
4	9.9						36	60	98	100												Silty sand	SM	Note (uu)	
6	16.5						4	16	70	92	98	99	100				0.36	0.22	0.14	2.57	0.96	Sand	SP	Note (vv)	

SOIL CLASSIFICATION RECORD SHEET

PROJECT: ROCHESTER FLOOD CONTROL, BEAR CREEK | BORING: 89-261 thru 89-275 | NED LAB NO. 90/280

STATION: | RANGE: | SURP. ELEV.: | DEPTH TO WATER TABLE:

TABLE C-10

SAMP NO.	DEPTH TO BOTTOM OF SAMP	MOISTURE (%)	PLASTICITY (ATT. LIMITS) LL	PLASTICITY (ATT. LIMITS) PI	HYD. ANALYSIS FINES .005	HYD. ANALYSIS FINES .02mm	GRADING (CUMULATIVE PERCENTS FINER) U.S. STANDARD SIEVE SIZE 200	SANDS 80	SANDS 40	SANDS 20	SANDS 10	SANDS 4	GRAVEL 3/8	GRAVEL 3/4	GRAVEL 1-1/2	GRAVEL 3 IN	GRADATION CURVE ANALYSIS D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc	CLASSIFICATION TECH MEMO 3-357, MAY 67		REMARKS	PL
Hole	89-261																								
2	5.9						4	8	60	78	83	85	88	90	100		0.42	0.26	0.18	2.33	0.89	Gravelly sand	SP	Note (ww)	
3	9.8						4	10	47	84	96	99	100				0.53	0.30	0.18	2.94	0.94	Sand	SP	Note (xx)	
Hole	89-263																								
2	5.7		22	10			28	39	59	69	75	80	82	89	100							Gravelly clayey Sand	SC	Note (yy)	12
Hole	89-266																								
2	5.7		41	24			46	66	81	84	88	91	91	94	100							Clayey sand	SC	Note (zz)	17
Hole	89-267																								
3	6.6		NP	NP			12	42	81	88	91	95	99	100			0.26	0.13	0.07	3.71	0.93	Silty sand	SM-SP	Note (ab)	
Hole	89-269																								
2	4.0						13	25	68	75	76	78	82	88	100							Silty gravelly sand	SM	Note (ac)	
Hole	89-270																								
2	6.6		25	12			30	36	55	67	70	72	73	74	74	100						Gravelly clayey Sand	SC	Note (ad)	13
3	12.1						6	10	20	29	38	47	64	74	100		8.20	0.84	0.17	48.24	0.51	Silty sandy gravel	GM-GP	Note (ae)	
Hole	89-271																								
3	7.1						7	14	42	59	69	76	87	96	100		0.90	0.30	0.13	6.92	0.77	Silty grav. sand	SM-SP	Note (af)	
Hole	89-272																								
2	6.8						2	4	58	85	90	91	92	92	100		0.44	0.28	0.20	2.20	0.89	Sand	SP	Note (ag)	
4	14.5						14	17	28	38	47	53	63	80	100							Silty sandy gravel	GM	Note (ah)	
Hole	89-273																								
3	6.7						5	6	35	59	70	80	90	96	100		0.86	0.37	0.21	4.10	0.76	Silty grav. sand	SM-SP	Note (ai)	
5	15.9		44	25			89	92	97	99	99	100										Sandy clay	CL	Note (aj)	
6	20.7		38	23			60	72	94	98	99	100										Sandy clay	CL	Note (ak)	
8	26.9						14	20	50	75	88	93	97	100								Silty sand	SM	Note (al)	
Hole	89-274																								
1	4.1						29	44	81	92	96	98	100									Silty sand	SM	Note (am)	
2	5.9						7	10	30	45	51	56	74	89	100		5.69	0.41	0.17	33.47	0.17	Silty grav. sand	SM-SP	Note (an)	
3	9.3						10	14	24	36	53	69	87	96	100		3.02	0.60	0.07	43.14	1.70	Silty grav. sand	SM-SW	Note (ao)	
Hole	89-275																								
5	17.1						4	14	65	87	96	98	100									Sand	SP	Note (ap)	
6	22.2		NP	NP			14	44	88	97	99	100										Silty sand	SM	Note (aq)	
7	25.9						4	11	59	84	94	97	99	100			0.42	0.26	0.17	2.47	0.95	Sand	SP	Note (ar)	

SOIL CLASSIFICATION RECORD SHEET

PROJECT: ROCHESTER FLOOD CONTROL, BEAR CREEK | BORING: 89-276 | MRD LAB NO. 90/280

STATION: | RANGE: | SURF.ELEV.: | DEPTH TO WATER TABLE:

TABLE C-10

SAMP NO.	DEPTH TO BOTTOM OF SAMP	MOISTURE (%)	PLASTICITY (ATT. LIMITS) LL	PI	GRADING (CUMULATIVE PERCENTS FINER) HYD. ANALYSIS FINES .005	.02mm	U.S. STANDARD SIEVE SIZE SANDS 200	80	40	20	10	4	GRAVEL 3/8	3/4	1-1/2	3 IN	GRADATION CURVE ANALYSIS D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc	CLASSIFICATION TECH MEMO 3-357, MAY 67	REMARKS	PL
Hole	89-276																							
6	16.9						12	36	89	99	100						0.26	0.15	0.07	3.71	1.24	Silty sand SM-SP	Note (as)	
7	19.2						6	29	86	97	99	100					0.28	0.18	0.09	3.11	1.29	Silty sand SM-SP	Note (at)	
11	36.9						6	17	55	73	87	95	99	100			0.50	0.24	0.12	4.17	0.96	Silty sand SM-SP	Note (au)	

TABLE C-11

DEPARTMENT OF THE ARMY
Missouri River Division, Corps of Engineers
Division Laboratory
Omaha, Nebraska

TABLE 1 - SUMMARY OF CLASSIFICATION TESTS

Project: Rochester Flood Control MRD Lab No. 90/280
Bear Creek

Holes 89-244 thru 89-276

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Note: By visual examination and classification, samples not tested were compared and grouped with typical test samples described below:

(a) Silty gravelly sand SM. Fine sand to fine gravel. Nonplastic. Similar to sample 2, Hole 89-244 (17% Fines, 54% Sand, 29% Gravel).

(b) Silty sand SM. Fine to medium sand. Nonplastic. Similar to sample 3, Hole 89-244 (19% Fines, 81% Sand).

(c) Sand SP. Fine to medium sand. Nonplastic. Similar to sample 4, Hole 89-244 (3% Fines, 90% Sand, 7% Gravel; Cu- 2.03, Cc- 0.95).

(d) Silty sand SM. Fine to medium sand. Nonplastic. Similar to sample 2, Hole 89-245 (16% Fines, 83% Sand, 1% Gravel).

(e) Gravelly clayey Sand SC. Fine sand to fine gravel. Medium tough at plastic limit. Similar to sample 2, Hole 89-246 (31% Fines, 54% Sand, 15% Gravel; LL-23.6, PI-11.6).

(f) Sand SP. Fine to medium sand. Nonplastic. Similar to sample 4, Hole 89-247 (0.4% Fines, 99.6% Sand; Cu- 2.31, Cc- 1.02).

(g) Silty sand SM-SP. Fine sand. Nonplastic. Similar to sample 6, Hole 89-247 (10% Fines, 90% Sand; Cu- 3.47, Cc- 1.19).

(h) Sandy gravelly clay CL-ML. Fine sand to coarse gravel. Soft at plastic limit. Similar to sample 8, Hole 89-247 (54% Fines, 22% Sand, 24% Gravel; LL-24, PI-6.8).

(i) Gravelly sand SP. Fine sand to fine gravel. Nonplastic. Similar to sample 2, Hole 89-248 (3% Fines, 75% Sand, 22% Gravel; Cu- 5.2, Cc- 0.62).

(j) Silty sand SM-SP. Fine sand. Nonplastic. Similar to sample 4, Hole 89-248 (11% Fines, 89% Sand; Cu- 3.11, Cc- 0.93).

(k) Silty sand SM-SP. Fine to medium sand. Nonplastic. Similar to sample 5, Hole 89-248 (6% Fines, 93% Sand, 1% Gravel; Cu- 3.23, Cc- 1.12).

TABLE C-12

CENCS-ED-GH (1110-1-261a) 4 November 1991
Crum/dac/645

MEMORANDUM FOR Dave Tschida

SUBJECT: Rochester Flood Control Project
Stage 4, Bear Creek FDM
Soil Parameters (revised)

1. The following are suggested soil parameters for use in designing the subject project. The subsurface exploration has indentified predominantly granular soils existing at the site. These soils (catagories a & b) may be assumed for all structures not bearing on rock. Catagory b should be used for random fill not including organics, debris or cohesive soils .

a. on-site granular soils (SP, SM, SC, GM)

Cohesion,	$c = 0$		
Moist Unit Weight,	$\gamma_m = 115$ pcf		
Saturated Unit Weight,	$\gamma_{sat} = 125$ pcf		
Void ratio,	$e = 0.69$		
Relative Density,	$D_r = 60\%$		
Friction Angles:		internal,	$\phi = 33°$
		soil & mass concrete,	$\delta = 26°$

b. Backfill (random and clean pervious fill)

Cohesion,	$c = 0$		
Moist Unit Weight,	$\gamma_m = 120$ pcf		
Saturated Unit Weight,	$\gamma_{sat} = 125$ pcf		
Friction Angles:		internal,	$\phi = 33°$
		soil & mass concrete,	$\delta = 26°$

c. Bedrock

Unit Weight (saturated),	γ	=	160 pcf
Cohesion,	c	=	50 psi
Internal Friction Angle,	ϕ	=	0°
Allowable Bearing Capacity,	q	=	12 tsf (167 psi)

2. Strength parameters to be verified with geology/geotech since there are some soils indentified in the soil borings that may not be representative of the properties as listed above. Some areas of sandstone contain zones that are uncemented and friable. There are also some isolated areas of cohesive soils and buried topsoils.

3. Suplemental parameters including interface friction in rock joints/planes, interface friction between soil and formed concrete, etc. should not be assumed without consultation with geology/geotech.

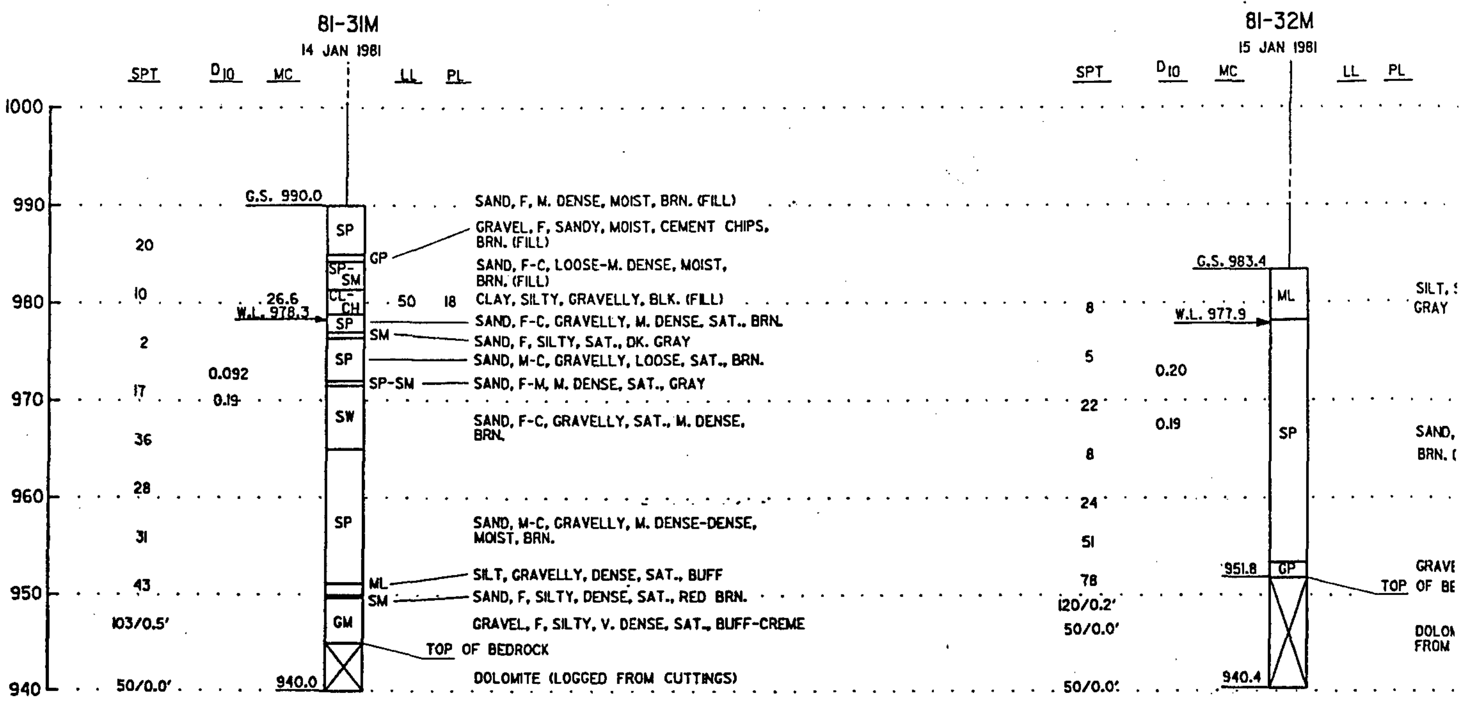
4. POC is the undersigned.

Douglas A. Crum
Civil Engineer

APPENDIX C

GEOTECHNICAL DESIGN

BORING LOGS



NOTES:

1. WATER LEVEL DETERMINED AFTER 20 MINUTES WITH BOTTOM OF AUGER TO EL. 975.0 AND BOTTOM OF HOLE AT EL. 976.0
2. HOLLOW STEM AUGER SET TO EL. 971.0. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 971.0. DRILLED WITH 2⅞ IN. TRICONE BIT BELOW EL. 945.0.
3. WATER LOSS AT EL. 970.0 TO 975.0, EST. 15 GPM. 100 PERCENT WATER LOSS BELOW EL. 950.0.
4. HOLE BACKFILLED WITH SAND - CEMENT GROUT MIXTURE.

NOTES:

1. WATER LEVEL DETERMINED AFTER 5 MIN. WITH BOTTOM AUGER AT EL. 974.4 AND BOTTOM OF HOLE AT EL. 97
2. HOLLOW STEM AUGER SET TO EL. 974.4. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 974.4. DRILLED WITH 2⅞ IN. TRICONE BIT BELOW EL. 950.4.
3. HOLE BACKFILLED WITH SOILS AND CAPPED WITH CEME

GENERAL BORING LEGEND

84-1M	YEAR OF BORING-BORING NUMBER, BORING TYPE (EG: M=MACHINE, A=AUGER, TP=TEST PIT, P=PIEZOMETER).
1 MAY 1984	DATE OF BORING
G.S. 1020.2	GROUND SURFACE ELEVATION AT BORING
GW	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURE, LITTLE OR NO FINES
GP	POORLY GRADED GRAVELS, LITTLE OR NO FINES
GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
SM	SILTY SANDS, SAND - SILT MIXTURES
SC	CLAYEY SANDS, SAND - CLAY MIXTURES
ML	INORGANIC SILTS, LIQUID LIMIT LESS THAN 50
MH	INORGANIC SILTS, LIQUID LIMIT GREATER THAN 50
CL	INORGANIC CLAYS, LOW TO MEDIUM PLASTICITY, LIQUID LIMIT LESS THAN 50
CH	INORGANIC CLAYS, HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
OL	ORGANIC SILTS OR CLAYS, LOW PLASTICITY, LIQUID LIMIT LESS THAN 50
OH	ORGANIC SILTS OR CLAYS, MEDIUM TO HIGH PLASTICITY, LIQUID LIMIT GREATER THAN 50
PT	PEAT
SP-SM	BORDERLINE MATERIAL
SP& SM	STRATIFIED MATERIAL
1	LOCATION AND SAMPLE NUMBER FOR UNDISTURBED SAMPLE
	NO RECOVERY
W.L. 726.7	WATER LEVEL ON DATE OF BORING
700	ELEVATION AT BOTTOM OF BORING

ROCK LEGEND

LIMESTONE - DOLOMITE
THIN TO MED. BEDDED, FLAT TO WAVY BEDDED, HAI TO WELL CEMENTED, SL. WEATHERED TO V. WEATHE FRACTURES, SL. POROUS TO SOLID, SL. VUGGY. OC STAINING AND VARIABLE DOLOMITIZATION, GRAY - E

SANDY LIMESTONE - SANDY DOLOMITE
SILTY TO V. SANDY AND OCCASIONALLY GLAUCONITI MED. MEDDED, FLAT TO WAVY BEDDING, MOD. HARD CEMENTED, SL. WEATHERED TO V. WEATHERED, SCA FRACTURES, SL. POROUS TO SOLID, OCCASIONAL IR OCCASIONALLY VUGGY, BRN. - GRAY - TAN

SHALEY LIMESTONE - SHALEY DOLOMITE
SILTY AND CLAYEY TO V. SANDY, THIN TO MED. BE WAVY LAMINATIONS, MOD. HARD, V. WEATHERED, SC AND THIN SHALE PARTINGS ALONG BEDDING PLANES, OCCASIONALLY VUGGY, SL. FISSILE, OCCASIONAL IR GRAY, OLIVE, TAN, AND BROWN

OOLITIC LIMESTONE
THIN TO MED. BEDDED, SOFT TO V. HARD, UNCEMEN CEMENTED, SL. POROUS TO SOLID, VUGGY, SCATTEF SILICEOUS REPLACEMENT ZONES, GRAY, BUFF, AND

SANDSTONE
QUARTZOSE, THIN TO MED. BEDDED, FLAT BEDDED \ CROSS BEDDING, POOR TO MOD. CEMENTATION, NOI CALCAREOUS, OCCASIONALLY DOLOMITIC, FINE TO M FRIABLE TO HARD, SL. WEATHERED TO UNWEATHERE SL. POROUS TO POROUS, COMMONLY IRON STAINED, INTERBEDDED WITH LIMESTONE AND DOLOMITE. BROW

SHALE - DOLOMITIC SHALE
SILTY, LAMINATED TO THIN BEDDED WITH SANDY, S INTERBEDS, FLAT TO WAVY BEDDING, SOFT TO MED WELL CEMENTED, FINE TEXTURE, OCCASIONALLY FIS TO V. WEATHERED, NON-CALCAREOUS TO CALCAREOL OLIVE TO YELLOW - BROWN TO TAN - GRAY

SILTSTONE - MUDSTONE
THIN BEDDED, SOFT TO MOD. HARD, POOR TO WELL WEATHERED, SL. CALCAREOUS, SCATTERED FRACTUR POROUS, BUFF

RESIDUUM
COMPOSED OF SL. WEATHERED TO V. WEATHERED ROCH OF SANDSTONE, LIMESTONE, DOLOMITE, OR SHALE, WI CLAY AND SILT COMPOSING THE MATRIX. MATERIAL CI RESIDUUM IS CONSIDERED TRANSITIONAL BETWEEN THE AND THE OVERBURDEN SOILS

81-32M

15 JAN 1981

] MC | LL PL

G.S. 983.4 — ML — SILT, SANDY, LOOSE, DRY-MOIST, BLK-GRAY

W.L. 977.9

20

19 — SP — SAND, F-C, GRAVELLY, LOOSE-DENSE, BRN. GRAY

951.8 — GP — GRAVEL, F-C, V. DENSE, SAT., BUFF-BRN.

TOP OF BEDROCK

DOLOMITE AND SANDSTONE (LOGGED FROM CUTTINGS)

940.4

DETERMINED AFTER 5 MIN. WITH BOTTOM OF
974.4 AND BOTTOM OF HOLE AT EL. 973.4.
AUGER SET TO EL. 974.4.
ED WITH DRILLING MUD BELOW EL. 974.4.
2⅞ IN. TRICONE BIT BELOW EL. 950.4.
.ED WITH SOILS AND CAPPED WITH CEMENT.

81-33M

16 JAN 1981

SPT D_{10} MC | LL PL

G.S. 996.4 — ML — SILT, GRAVELLY, LOOSE-M. DENSE, DRY, E

SP — SAND, F, LOOSE, MOIST, BRN.

8 0.10 990.7

TOP OF BEDROCK

SANDSTONE, THIN BEDDED, F-M, MOD. HARD, SL. WEATHERED, OPEN JOINTS, VUGGY

LIMESTONE, DOLOMITIC, CALCAREOUS, F-M, THIN BEDDED, BUFF

SANDSTONE, THIN BEDDED, MOD. CEMENTED, SOFT-HARD, WEATHERED

SHALE-MUDSTONE, GLAUCONITIC, THIN BEDDED POORLY -MOD. CEMENTED, SL.WEATHERED, GRN

LIMESTONE, DOLOMITIC

RQD	%REC
28	95
34	94

981.9

NOTES:
1. WATER LEVEL WAS NOT DETERMINED.
2. HOLLOW STEM AUGER SET TO EL. 991.4.
3. CORE BARREL USED BELOW EL. 990.7.

CK LEGEND

DOLOMITE
BEDDED, FLAT TO WAVY BEDDED, HARD TO V. HARD, MOD.
:NTED, SL. WEATHERED TO V. WEATHERED, SCATTERED TIGHT
.. POROUS TO SOLID, SL. VUGGY. OCCASIONAL IRON
VARIABLE DOLOMITIZATION, GRAY - BRN. - BUFF.

;TONE - SANDY DOLOMITE
SANDY AND OCCASIONALLY GLAUCONITIC, LAMINATED TO
FLAT TO WAVY BEDDING, MOD. HARD TO V. HARD TO WELL
. WEATHERED TO V. WEATHERED, SCATTERED TIGHT
L. POROUS TO SOLID, OCCASIONAL IRON STAINING AND
VUGGY, BRN. - GRAY - TAN

:STONE - SHALEY DOLOMITE
AYEY TO V. SANDY, THIN TO MED. BEDDED, OCCASIONAL
'IONS, MOD. HARD, V. WEATHERED, SCATTERED FRACTURES
LE PARTINGS ALONG BEDDING PLANES, SOLID,
VUGGY, SL. FISSILE, OCCASIONAL IRON STAIN, YELLOW,
TAN, AND BROWN

ESTONE
BEDDED, SOFT TO V. HARD, UNCEMENTED TO WELL
. POROUS TO SOLID, VUGGY, SCATTERED FRACTURES AND
PLACEMENT ZONES, GRAY, BUFF, AND TAN

'HIN TO MED. BEDDED, FLAT BEDDED WITH OCCASIONAL
IG, POOR TO MOD. CEMENTATION, NON-CALCAREOUS TO
OCCASIONALLY DOLOMITIC, FINE TO MED. TEXTURE,
IARD, SL. WEATHERED TO UNWEATHERED, PITTED TO SOLID,
'D POROUS, COMMONLY IRON STAINED, FREQUENTLY
WITH LIMESTONE AND DOLOMITE. BROWN - WHITE - BUFF

LOMITIC SHALE
ATED TO THIN BEDDED WITH SANDY, SILTY, AND CLAYEY
LAT TO WAVY BEDDING, SOFT TO MED. HARD, POORLY TO
ED, FINE TEXTURE, OCCASIONALLY FISSILE, SL. WEATHERED
:RED, NON-CALCAREOUS TO CALCAREOUS, GRAY - GREEN TO
.LOW - BROWN TO TAN - GRAY

- MUDSTONE
SOFT TO MOD. HARD, POOR TO WELL CEMENTED, SL.
;L. CALCAREOUS, SCATTERED FRACTURES, SL. FISSILE, SL.

SL. WEATHERED TO V. WEATHERED ROCK SLABS; FRAGMENTS
: LIMESTONE, DOLOMITE, OR SHALE WITH SAND, GRAVEL,
T COMPOSING THE MATRIX. MATERIAL CLASSIFIED AS
CONSIDERED TRANSITIONAL BETWEEN THE TOP OF BEDROCK
IBURDEN SOILS

GENERAL BORING NOTES

1. GENERAL: THE UNIFIED SOIL CLASSIFICATION SYSTEM IS USED TO IDENTIFY BASIC SOIL TYPE. 1 REPRESENTS ONLY THE BASIC SOILS. TO COMPLETE THE CLASSIFICATION, PERTINENT INFC IS ADDED TO THE RIGHT OF THE BORING STAFF. NOTES PERTAINING TO A SPECIFIC BORI SHOWN BELOW THE BORING STAFF.

2. MOISTURE CONTENT: THE NATURAL MOISTURE CONTENT IN PERCENT OF DRY WEIGHT (MC) IS SHOWN TO THE L THE BORING STAFF.

3. BLOW COUNT (SPT): BLOW COUNTS ARE SHOWN TO THE LEFT OF THE BORING STAFF AND, EXCEPT AS NOTE OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12". STANDARD BL ARE FOR A STANDARD PENETRATION TEST (SPT) USING A 1-3/8" X 2" SAMPLER, 140 LB. H DROP. FOR NON-STANDARD BLOW COUNTS, SAMPLER SIZE, HAMMER WEIGHT AND HEIGHT O ARE AS SHOWN.

4. ATTERBERG LIMITS: LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL) ARE SHOWN TO THE RIGHT OF THE BORING S

5. D_{10} SIZES: THE GRAIN SIZE IN MILLIMETERS OF WHICH 10% OF THE SAMPLE IS FINER IS SHOWN TO OF THE BORING STAFF.

6. RQD / % REC: ROCK QUALITY DESIGNATION (RQD) AND PERCENT RECOVERY OF CORED ROCK (% REC) IS THE LEFT OF THE BORING STAFF. RQD IS THE PERCENT RECOVERY OF UNBROKEN PIECE THAN 0.3 FOOT. % REC IS THE PERCENT RECOVERY OF ALL PIECES WITH RESPECT TO LOST CORE.

SYMBOL	DESCRIPTION

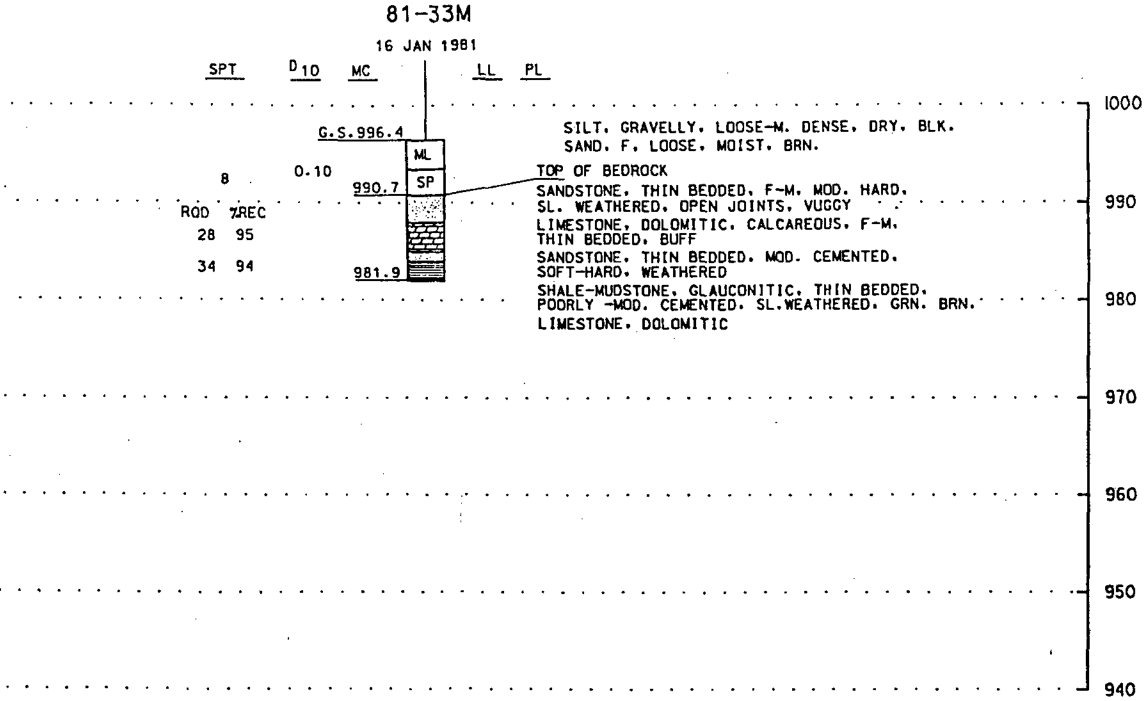
DE
ST. P.

AE APPROVING OFFICIAL:

BORIN
FLOOD CONTROL - SOU
ROCHESTER
STAGE 4 -
BORING LOGS 81-

ED-D: DESIGNED: / CHECKED: / DRAWN:
ED-GH: DESIGNED: LJL / CHECKED: DAC
DATE: 05-22-90
CAD FILE NAME: PLATELOGN
SPEC NO: DACW37-90-B-0000
DR

2



NOTES:

1. WATER LEVEL WAS NOT DETERMINED.
2. HOLLOW STEM AUGER SET TO EL. 991.4.
3. CORE BARREL USED BELOW EL. 990.7.

GENERAL BORING NOTES

GENERAL: THE UNIFIED SOIL CLASSIFICATION SYSTEM IS USED TO IDENTIFY BASIC SOIL TYPE. THE LEGEND REPRESENTS ONLY THE BASIC SOILS. TO COMPLETE THE CLASSIFICATION, PERTINENT INFORMATION IS ADDED TO THE RIGHT OF THE BORING STAFF. NOTES PERTAINING TO A SPECIFIC BORING ARE SHOWN BELOW THE BORING STAFF.

MOISTURE CONTENT: THE NATURAL MOISTURE CONTENT IN PERCENT OF DRY WEIGHT (MC) IS SHOWN TO THE LEFT OF THE BORING STAFF.

BLOW COUNT (SPT): BLOW COUNTS ARE SHOWN TO THE LEFT OF THE BORING STAFF AND, EXCEPT AS NOTED, ARE THE NUMBER OF BLOWS NECESSARY TO DRIVE THE SAMPLER USED A DISTANCE OF 12". STANDARD BLOW COUNTS ARE FOR A STANDARD PENETRATION TEST (SPT) USING A 1-3/8" X 2" SAMPLER, 140 LB. HAMMER AND A 30" DROP. FOR NON-STANDARD BLOW COUNTS, SAMPLER SIZE, HAMMER WEIGHT AND HEIGHT OF DROP ARE AS SHOWN.

ATTERBERG LIMITS: LIQUID LIMIT (LL) AND PLASTIC LIMIT (PL) ARE SHOWN TO THE RIGHT OF THE BORING STAFF.

D_{10} SIZES THE GRAIN SIZE IN MILLIMETERS OF WHICH 10% OF THE SAMPLE IS FINER IS SHOWN TO THE LEFT OF THE BORING STAFF.

RQD / % REC ROCK QUALITY DESIGNATION (RQD) AND PERCENT RECOVERY OF CORED ROCK (% REC) IS SHOWN TO THE LEFT OF THE BORING STAFF. RQD IS THE PERCENT RECOVERY OF UNBROKEN PIECES LONGER THAN 0.3 FOOT. % REC IS THE PERCENT RECOVERY OF ALL PIECES WITH RESPECT TO LOST CORE.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

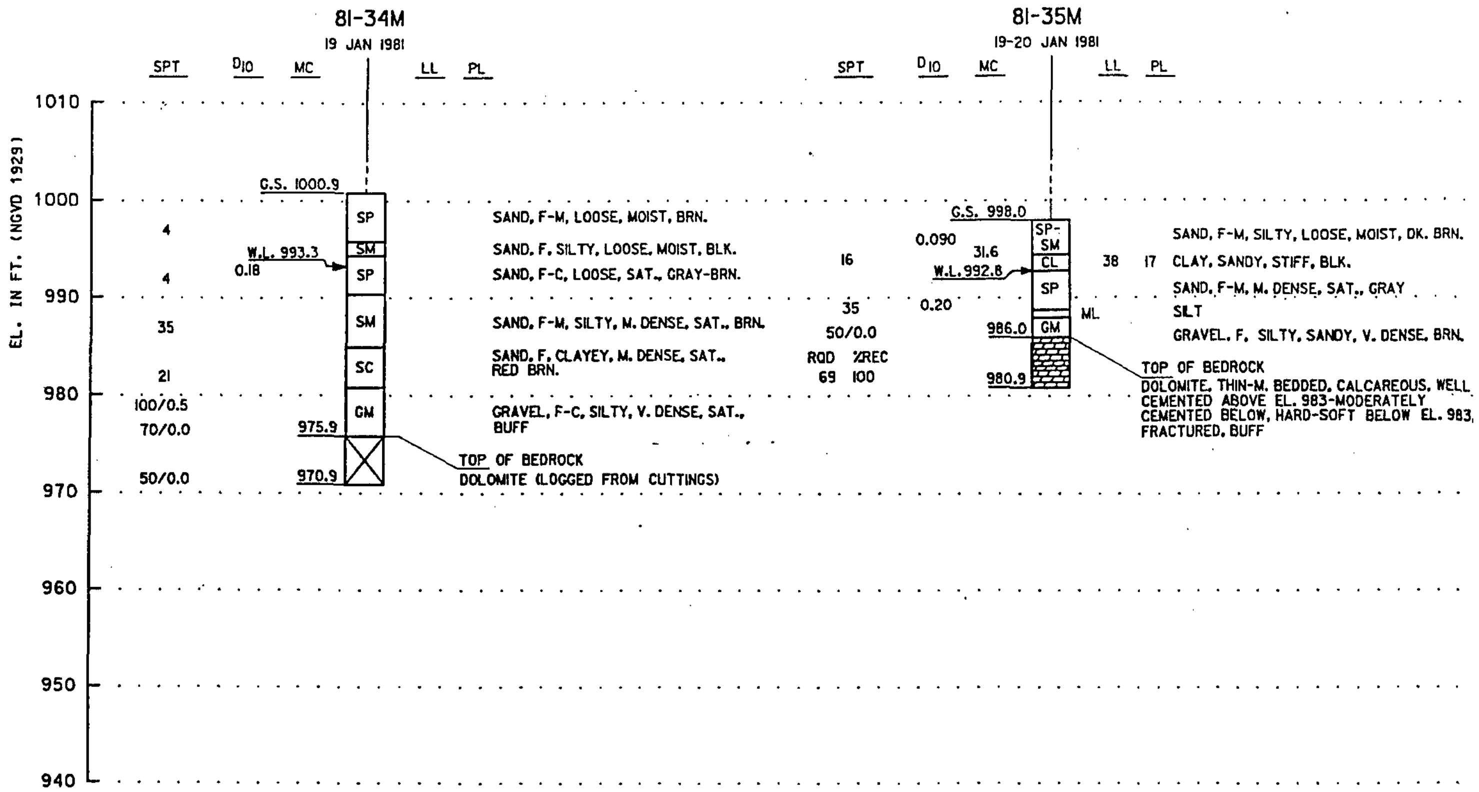
AE APPROVING OFFICIAL:

BORING LOGS
FLOOD CONTROL – SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 – BEAR CREEK
BORING LOGS 81-31M THRU 81-33M

ED-D	DESIGNED:
	CHECKED:
	DRAWN:
ED-GH	DESIGNED: CJL
	CHECKED: DAC
DATE: 05-22-90	

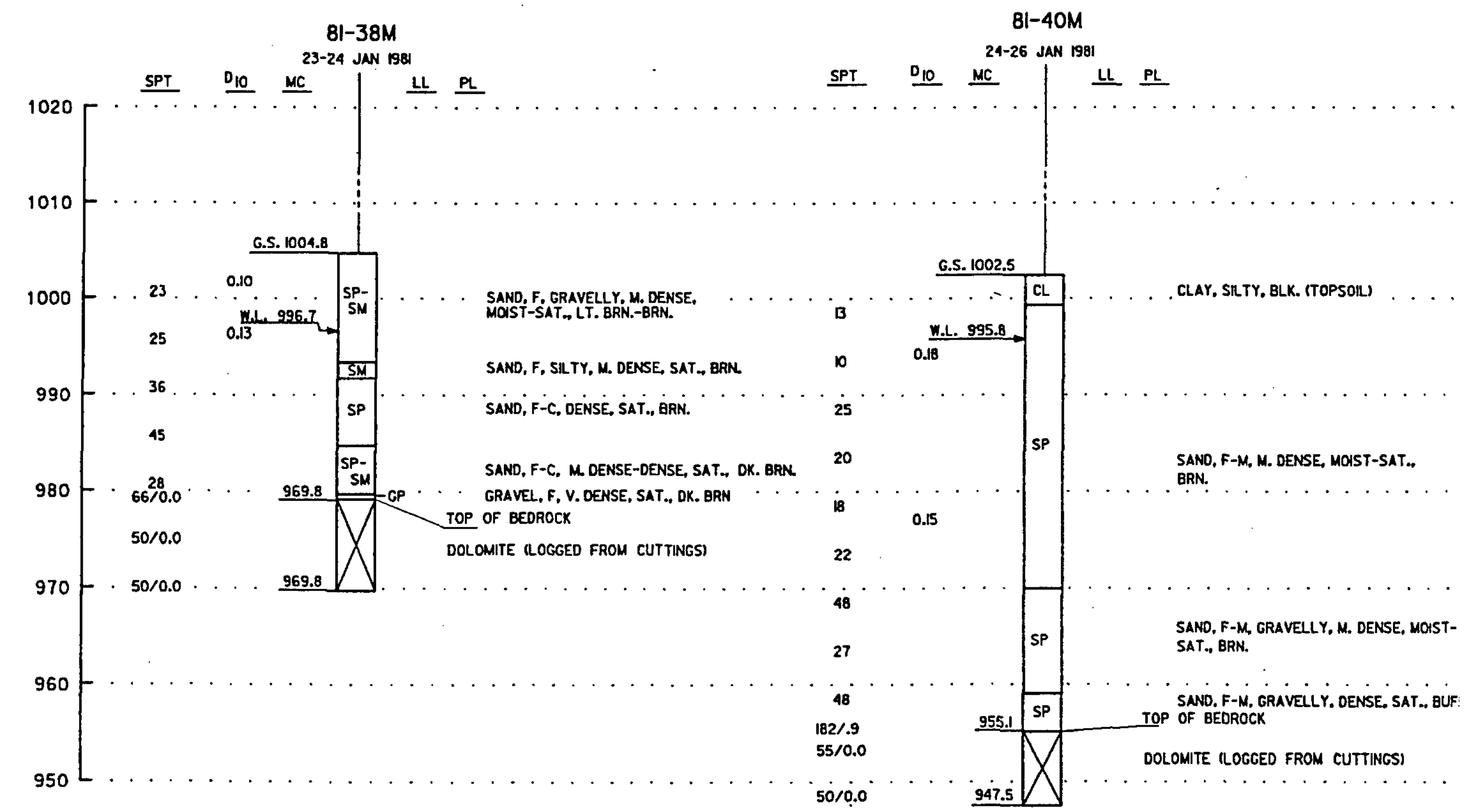
CAD FILE NAME: PLATE1.DGN
SPEC NO: DACW37-90-B-0000
DRAWING NUMBER: PLATE C-1
SHT 1 OF 7

3



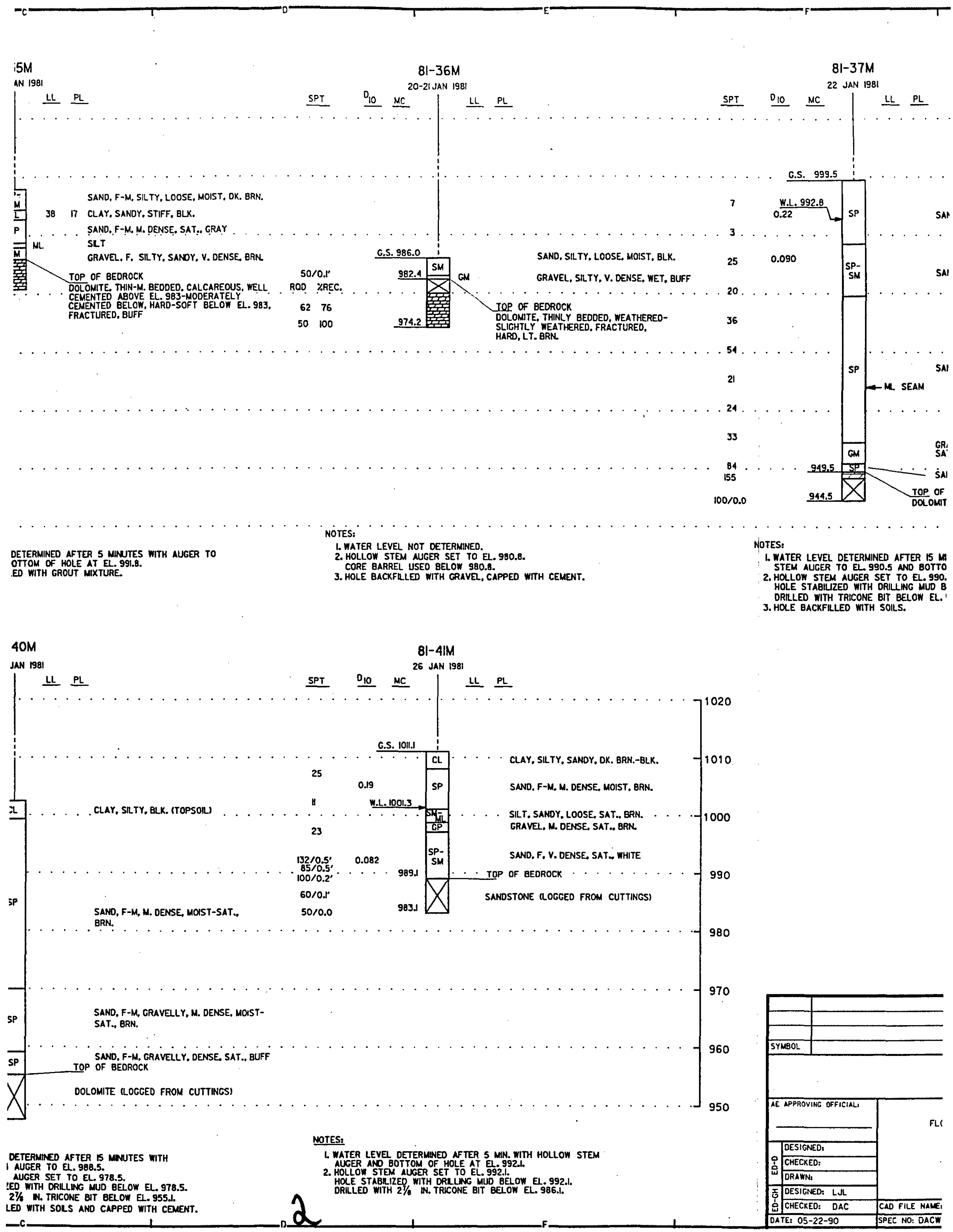
NOTES:
1. WATER LEVEL DETERMINED AFTER 10 MINUTES WITH AUGER TO EL. 990.9 AND BOTTOM OF HOLE AT EL. 990.6.
2. HOLLOW STEM AUGER SET TO EL. 986.9. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 986.9. DRILLED WITH 2⅞ IN. TRICONE BIT BELOW EL. 975.9.
3. HOLE BACKFILLED WITH SOIL.

NOTES:
1. WATER LEVEL DETERMINED AFTER 5 MINUTES WITH AUGER TO EL. 993 AND BOTTOM OF HOLE AT EL. 991.8.
2. HOLE BACKFILLED WITH GROUT MIXTURE.

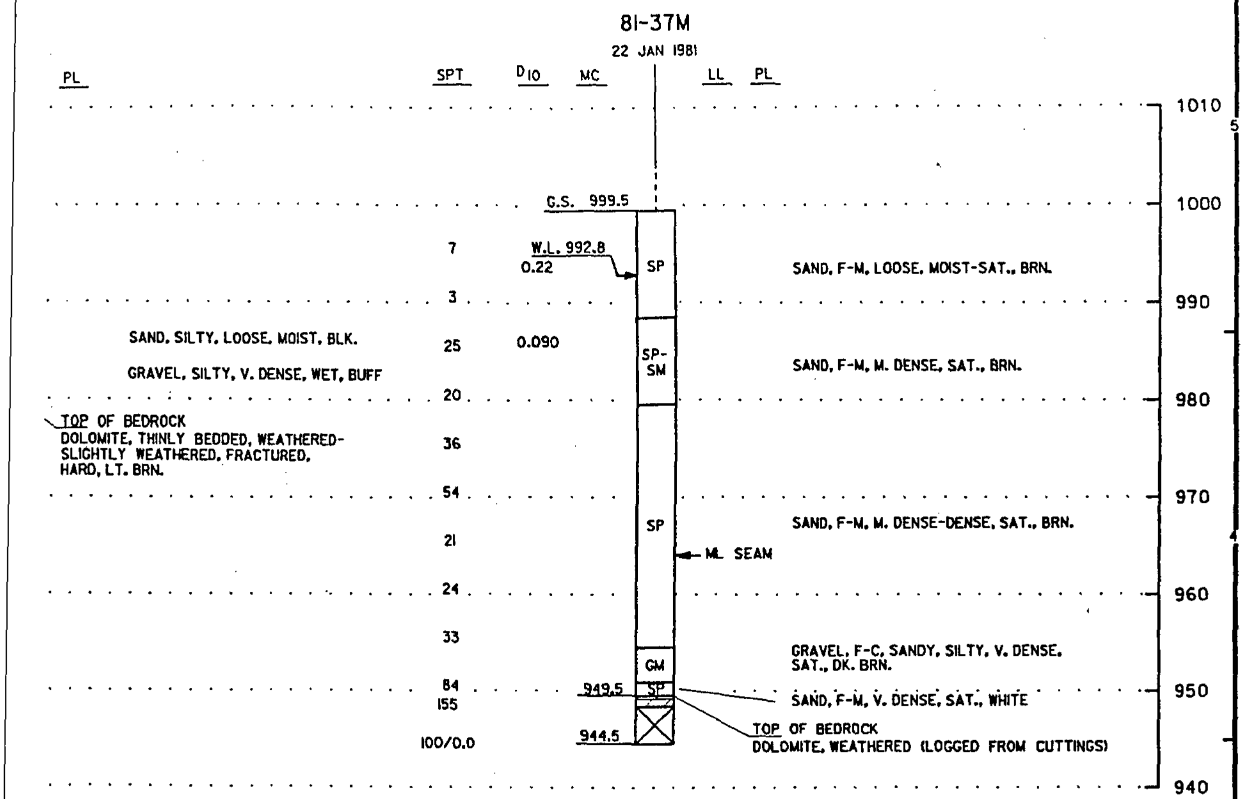


NOTES:
1. WATER LEVEL DETERMINED AFTER 5 MIN. WITH AUGER AND BOTTOM OF HOLE TO EL. 994.8.
2. HOLLOW STEM AUGER SET TO EL. 990.8. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 990.8. DRILLED WITH 2⅞ IN. TRICONE BIT BELOW EL. 979.1.
3. HOLE BACKFILLED WITH SAND AND CAPPED WITH CEMENT.

NOTES:
1. WATER LEVEL DETERMINED AFTER 15 MINUTES WITH HOLLOW STEM AUGER TO EL. 988.5.
2. HOLLOW STEM AUGER SET TO EL. 978.5. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 978.5. DRILLED WITH 2⅞ IN. TRICONE BIT BELOW EL. 955.1.
3. HOLE BACKFILLED WITH SOILS AND CAPPED WITH CEMENT.

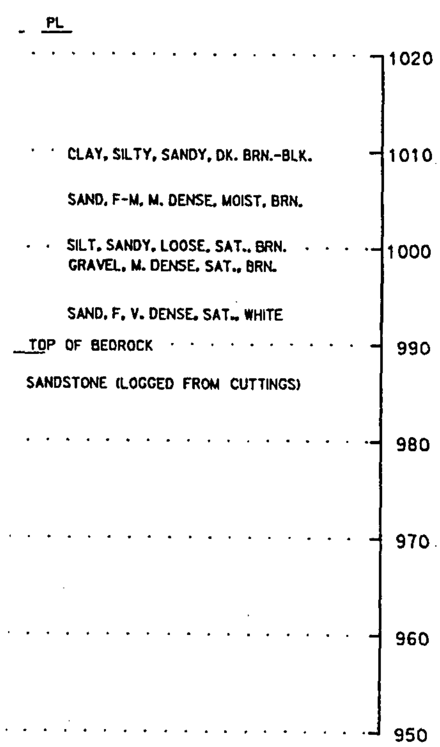


C
D
E
F
5M
AN 1981
LL PL
SAND, F-M, SILTY, LOOSE, MOIST, DK. BRN.
38 17 CLAY, SANDY, STIFF, BLK.
SAND, F-M, M. DENSE, SAT., GRAY
ML SILT
GRAVEL, F. SILTY, SANDY, V. DENSE, BRN.
TOP OF BEDROCK
DOLOMITE, THIN-M. BEDDED, CALCAREOUS, WELL CEMENTED ABOVE EL. 983-MODERATELY CEMENTED BELOW, HARD-SOFT BELOW EL. 983, FRACTURED, BUFF
DETERMINED AFTER 5 MINUTES WITH AUGER TO
OTTOM OF HOLE AT EL. 991.8.
ED WITH GROUT MIXTURE.
81-36M
20-21 JAN 1981
SPT D10 MC LL PL
G.S. 986.0
SM
982.4
GM
974.2
50/0.1'
RQD %REC.
62 76
50 100
SAND, SILTY, LOOSE, MOIST, BLK.
GRAVEL, SILTY, V. DENSE, WET, BUFF
TOP OF BEDROCK
DOLOMITE, THINLY BEDDED, WEATHERED-SLIGHTLY WEATHERED, FRACTURED, HARD, LT. BRN.
NOTES:
1. WATER LEVEL NOT DETERMINED.
2. HOLLOW STEM AUGER SET TO EL. 980.8. CORE BARREL USED BELOW 980.8.
3. HOLE BACKFILLED WITH GRAVEL, CAPPED WITH CEMENT.
81-37M
22 JAN 1981
SPT D10 MC LL PL
G.S. 999.5
W.L. 992.8
7 0.22 SP
3
25 0.090 SP-SM
20
36
54
21 SP
24
33
GM
84
155
949.5 SP
100/0.0
944.5
ML SEAM
SAI
SAI
SAI
GR
SA
SAI
TOP OF
DOLOMIT
NOTES:
1. WATER LEVEL DETERMINED AFTER 15 MI STEM AUGER TO EL. 990.5 AND BOTTO
2. HOLLOW STEM AUGER SET TO EL. 990. HOLE STABILIZED WITH DRILLING MUD B DRILLED WITH TRICONE BIT BELOW EL.
3. HOLE BACKFILLED WITH SOILS.
40M
JAN 1981
LL PL
CL CLAY, SILTY, BLK. (TOPSOIL)
SP SAND, F-M, M. DENSE, MOIST-SAT., BRN.
SP SAND, F-M, GRAVELLY, M. DENSE, MOIST-SAT., BRN.
SP SAND, F-M, GRAVELLY, DENSE, SAT., BUFF
TOP OF BEDROCK
DOLOMITE (LOGGED FROM CUTTINGS)
DETERMINED AFTER 15 MINUTES WITH
AUGER TO EL. 988.5.
AUGER SET TO EL. 978.5.
ED WITH DRILLING MUD BELOW EL. 978.5.
2 7/8 IN. TRICONE BIT BELOW EL. 955.1.
LED WITH SOILS AND CAPPED WITH CEMENT.
81-41M
26 JAN 1981
SPT D10 MC LL PL
G.S. 1011.1
CL
25 0.19 SP
11 W.L. 1001.3
SM-ML
GP
23
SP-SM
132/0.5' 0.082
85/0.5'
100/0.2'
989.1
60/0.1'
50/0.0
983.1
CLAY, SILTY, SANDY, DK. BRN.-BLK.
SAND, F-M, M. DENSE, MOIST, BRN.
SILT, SANDY, LOOSE, SAT., BRN.
GRAVEL, M. DENSE, SAT., BRN.
SAND, F, V. DENSE, SAT., WHITE
TOP OF BEDROCK
SANDSTONE (LOGGED FROM CUTTINGS)
1020
1010
1000
990
980
970
960
950
NOTES:
1. WATER LEVEL DETERMINED AFTER 5 MIN. WITH HOLLOW STEM AUGER AND BOTTOM OF HOLE AT EL. 992.1.
2. HOLLOW STEM AUGER SET TO EL. 992.1. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 992.1. DRILLED WITH 2 7/8 IN. TRICONE BIT BELOW EL. 986.1.
SYMBOL
AE APPROVING OFFICIAL:
FL(
ED-D
DESIGNED:
CHECKED:
DRAWN:
ED-GH
DESIGNED: LJL
CHECKED: DAC
DATE: 05-22-90
CAD FILE NAME:
SPEC NO: DACW
2



EL. 980.8.
).8.
, CAPPED WITH CEMENT.

NOTES:
1. WATER LEVEL DETERMINED AFTER 15 MINUTES WITH HOLLOW STEM AUGER TO EL. 990.5 AND BOTTOM OF HOLE AT EL. 990.9.
2. HOLLOW STEM AUGER SET TO EL. 990.5. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 990.5. DRILLED WITH TRICONE BIT BELOW EL. 948.4.
3. HOLE BACKFILLED WITH SOILS.



R 5 MIN. WITH HOLLOW STEM
AT EL. 992.1.
EL. 992.1.
MUD BELOW EL. 992.1.
BIT BELOW EL. 986.1.

3

SYMBOL	DESCRIPTION	DATE	APPROVAL

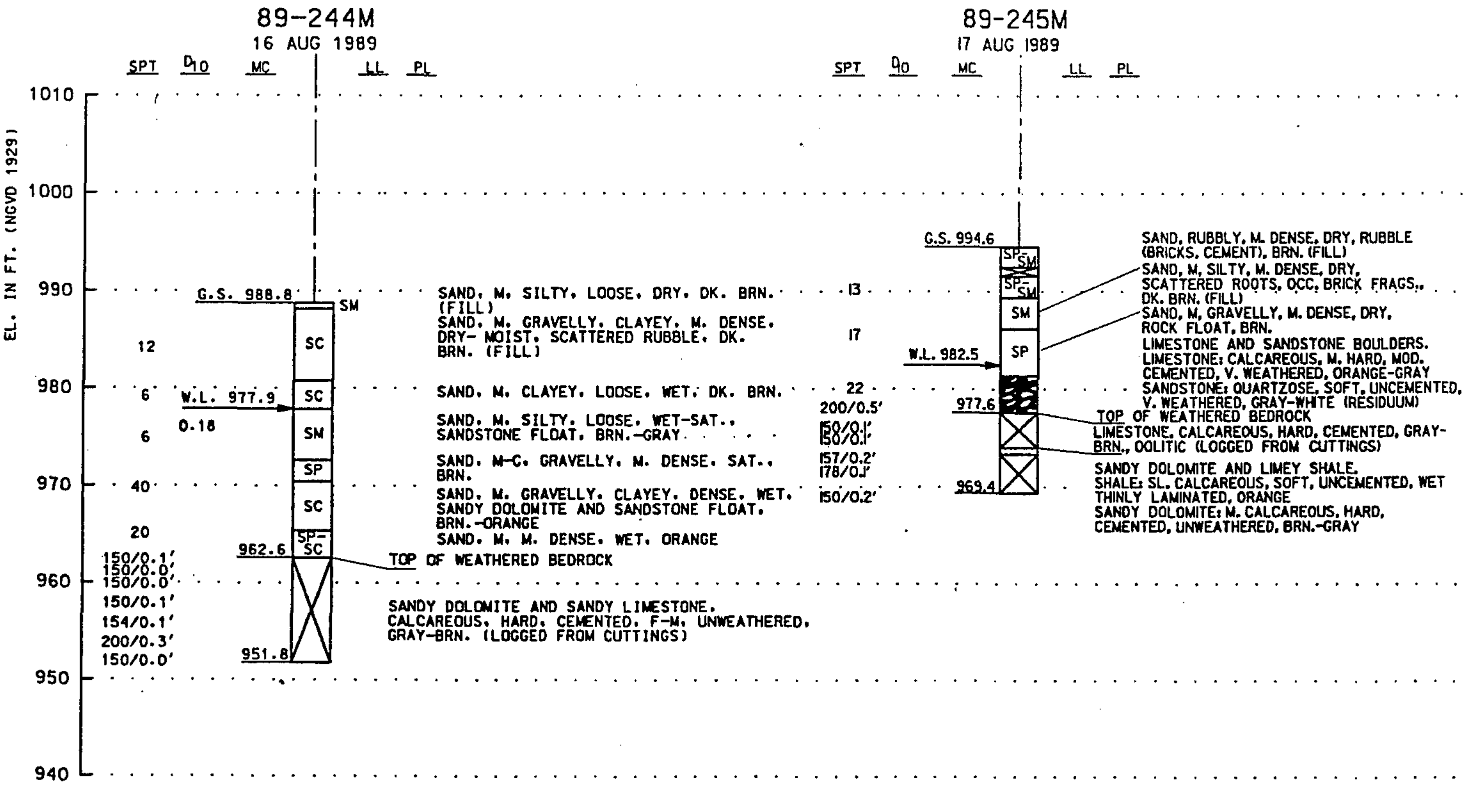
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

BORING LOGS
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
BORING LOGS 81-34M THRU 81-41M

ED-D: DESIGNED: / CHECKED: / DRAWN:
ED-GH: DESIGNED: LJL / CHECKED: DAC
DATE: 05-22-90

CAD FILE NAME: PLATE2.DGN
SPEC NO: DACW37-90-B-0000
DRAWING NUMBER: PLATE C-2
SHT 2 OF 7

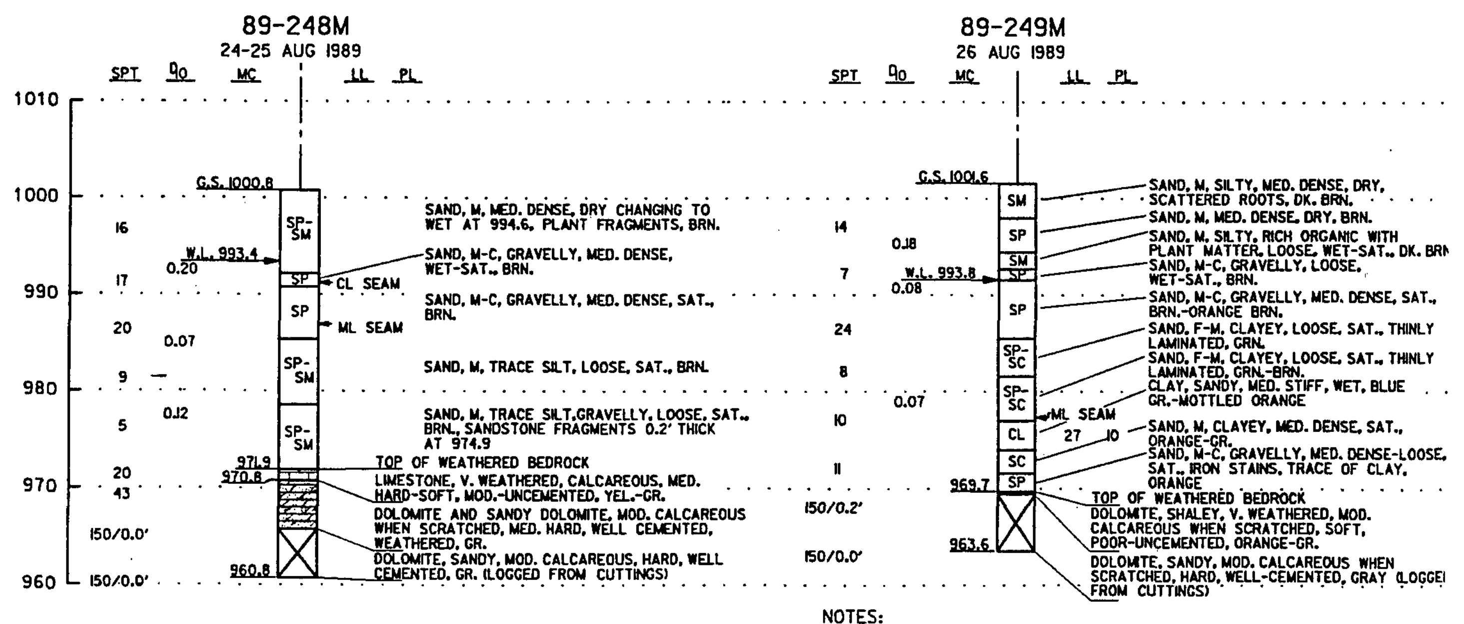


NOTES:

1. WATER LEVEL DETERMINED AFTER 15 MIN. WITH BOTTOM OF AUGER AT EL. 973.8 AND SAMPLING TO EL. 970.8. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 974.6.
2. HOLLOW STEM AUGER SET AT EL. 973.8. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 973.8.
3. WATER LOSS BELOW EL. 973.8 WAS BETWEEN 0 AND 5 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT MIXTURE.

NOTES:

1. WATER LEVEL DETERMINED AFTER 30 MIN. WITH BOTTOM OF AUGER AND SAMPLING TO EL. 979.6 . CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 979.9.
2. HOLLOW STEM AUGER SET AT EL. 979.6. HOLE STABLIZED WITH DRILLING MUD BELOW EL. 979.6.
3. NO WATER LOSS BELOW EL. 979.6.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

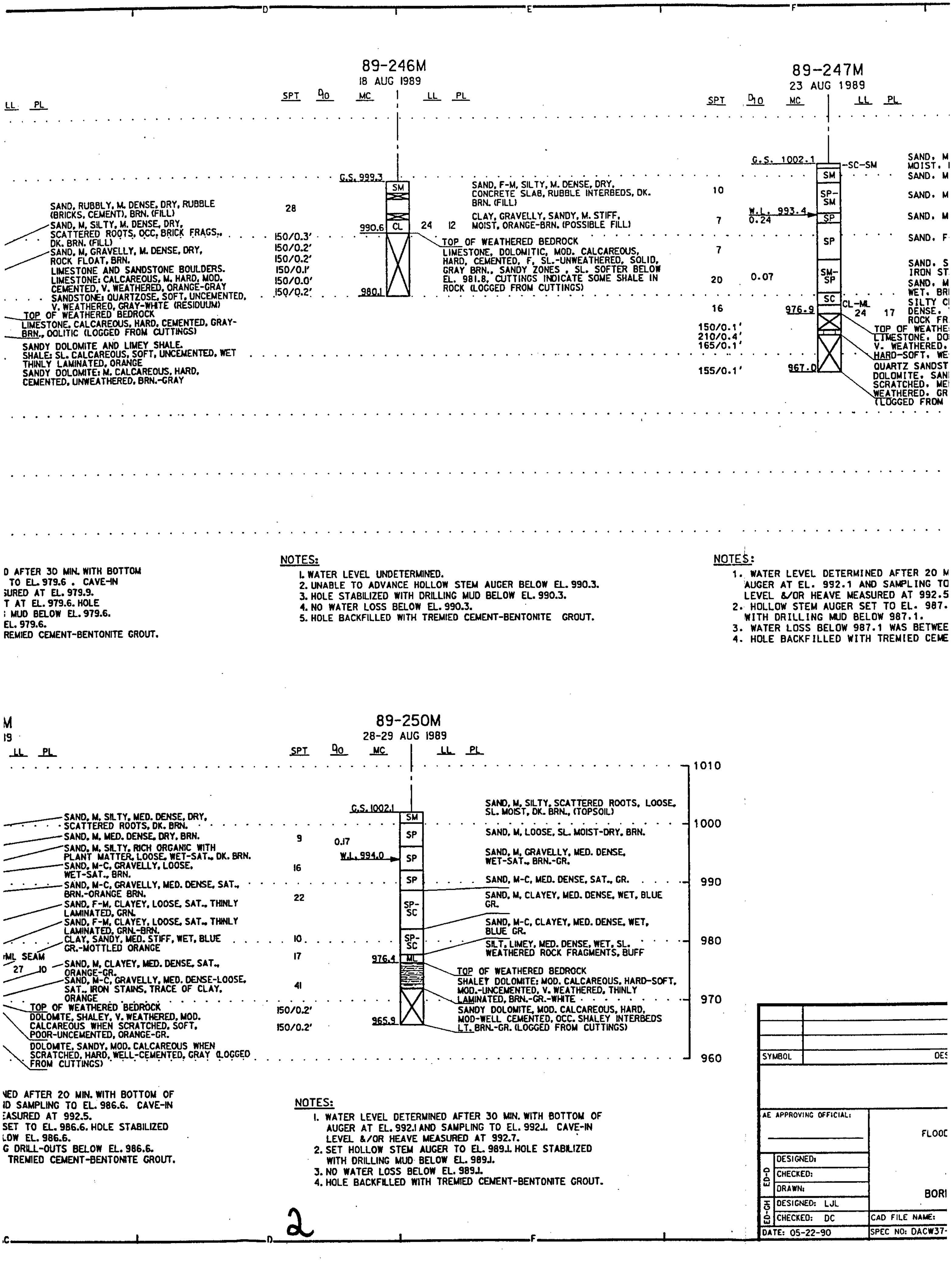


NOTES:

1. WATER LEVEL DETERMINED AFTER 20 MIN. WITH BOTTOM OF AUGER AT EL. 990.8 AND SAMPLING TO EL. 987.8. CAVE-IN LEVEL &/OR HEAVE MEASURED AT 991.5.
2. HOLLOW STEM AUGER SET TO EL. 990.8. DRILLING MUD USED TO STABILIZE HOLE BELOW 990.8.
3. 100 PERCENT WATER LOSS BELOW EL. 970.8.
4. HOLE BACKFILLED WITH A 10-FOOT BENTONITE PELLET PLUG FROM EL. 970.8 TO 960.8, AND A TREMIED CEMENT-BENTONITE GROUT FROM EL. 970.8 TO THE GROUND SURFACE.

NOTES:

1. WATER LEVEL DETERMINED AFTER 20 MIN. WITH BOTTOM OF AUGER AT EL. 991.6 AND SAMPLING TO EL. 986.6. CAVE-IN LEVEL &/OR HEAVE MEASURED AT 992.5.
2. HOLLOW STEM AUGER SET TO EL. 986.6. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 986.6.
3. NO WATER LOSS DURING DRILL-OUTS BELOW EL. 986.6.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



89-246M
18 AUG 1989
SPT D10 MC LL PL
G.S. 999.3
SM
CL
990.6
24 12
980.1
SAND, RUBBLY, M. DENSE, DRY, RUBBLE (BRICKS, CEMENT), BRN. (FILL)
28
SAND, M, SILTY, M. DENSE, DRY, SCATTERED ROOTS, OCC. BRICK FRAGS., DK. BRN. (FILL)
SAND, M, GRAVELLY, M. DENSE, DRY, ROCK FLOAT, BRN.
LIMESTONE AND SANDSTONE BOULDERS.
LIMESTONE: CALCAREOUS, M. HARD, MOD. CEMENTED, V. WEATHERED, ORANGE-GRAY
SANDSTONE: QUARTZOSE, SOFT, UNCEMENTED, V. WEATHERED, GRAY-WHITE (RESIDUUM)
TOP OF WEATHERED BEDROCK
LIMESTONE, CALCAREOUS, HARD, CEMENTED, GRAY-BRN., OOLITIC (LOGGED FROM CUTTINGS)
SANDY DOLOMITE AND LIMEY SHALE.
SHALE: SL. CALCAREOUS, SOFT, UNCEMENTED, WET THINLY LAMINATED, ORANGE
SANDY DOLOMITE: M. CALCAREOUS, HARD, CEMENTED, UNWEATHERED, BRN.-GRAY
150/0.3'
150/0.2'
150/0.2'
150/0.1'
150/0.0'
150/0.2'
SAND, F-M, SILTY, M. DENSE, DRY, CONCRETE SLAB, RUBBLE INTERBEDS, DK. BRN. (FILL)
CLAY, GRAVELLY, SANDY, M. STIFF, MOIST, ORANGE-BRN. (POSSIBLE FILL)
TOP OF WEATHERED BEDROCK
LIMESTONE, DOLOMITIC, MOD. CALCAREOUS, HARD, CEMENTED, F, SL.-UNWEATHERED, SOLID, GRAY BRN., SANDY ZONES, SL. SOFTER BELOW EL. 981.8, CUTTINGS INDICATE SOME SHALE IN ROCK (LOGGED FROM CUTTINGS)
89-247M
23 AUG 1989
SPT D10 MC LL PL
G.S. 1002.1
SC-SM
SM
SP-SM
W.L. 993.4
SP
SP
SM-SP
SC
CL-ML
976.9
24 17
967.0
10
7
0.24
7
20
0.07
16
150/0.1'
210/0.4'
165/0.1'
155/0.1'
SAND, M MOIST, I
SAND, M
SAND, M
SAND, M
SAND, F
SAND, S IRON ST
SAND, M WET, BRI
SILTY CI DENSE,
ROCK FR
TOP OF WEATHE
LIMESTONE, DO
V. WEATHERED,
HARD-SOFT, WE
QUARTZ SANDST
DOLOMITE, SAN
SCRATCHED, ME
WEATHERED, GR
(LOGGED FROM
D AFTER 30 MIN. WITH BOTTOM
TO EL. 979.6 . CAVE-IN
SURED AT EL. 979.9.
T AT EL. 979.6. HOLE
MUD BELOW EL. 979.6.
EL. 979.6.
REMIED CEMENT-BENTONITE GROUT.
NOTES:
1. WATER LEVEL UNDETERMINED.
2. UNABLE TO ADVANCE HOLLOW STEM AUGER BELOW EL. 990.3.
3. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 990.3.
4. NO WATER LOSS BELOW EL. 990.3.
5. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
NOTES:
1. WATER LEVEL DETERMINED AFTER 20 M
AUGER AT EL. 992.1 AND SAMPLING TO
LEVEL &/OR HEAVE MEASURED AT 992.5
2. HOLLOW STEM AUGER SET TO EL. 987.
WITH DRILLING MUD BELOW 987.1.
3. WATER LOSS BELOW 987.1 WAS BETWEE
4. HOLE BACKFILLED WITH TREMIED CEME
M
19
LL PL
SAND, M, SILTY, MED. DENSE, DRY, SCATTERED ROOTS, DK. BRN.
SAND, M, MED. DENSE, DRY, BRN.
SAND, M, SILTY, RICH ORGANIC WITH PLANT MATTER, LOOSE, WET-SAT., DK. BRN.
SAND, M-C, GRAVELLY, LOOSE, WET-SAT., BRN.
SAND, M-C, GRAVELLY, MED. DENSE, SAT., BRN.-ORANGE BRN.
SAND, F-M, CLAYEY, LOOSE, SAT., THINLY LAMINATED, GRN.
SAND, F-M, CLAYEY, LOOSE, SAT., THINLY LAMINATED, GRN.-BRN.
CLAY, SANDY, MED. STIFF, WET, BLUE GR.-MOTTLED ORANGE
ML SEAM
27 10
SAND, M, CLAYEY, MED. DENSE, SAT., ORANGE-GR.
SAND, M-C, GRAVELLY, MED. DENSE-LOOSE, SAT., IRON STAINS, TRACE OF CLAY, ORANGE
TOP OF WEATHERED BEDROCK
DOLOMITE, SHALEY, V. WEATHERED, MOD. CALCAREOUS WHEN SCRATCHED, SOFT, POOR-UNCEMENTED, ORANGE-GR.
DOLOMITE, SANDY, MOD. CALCAREOUS WHEN SCRATCHED, HARD, WELL-CEMENTED, GRAY (LOGGED FROM CUTTINGS)
NED AFTER 20 MIN. WITH BOTTOM OF
D SAMPLING TO EL. 986.6. CAVE-IN
EASURED AT 992.5.
SET TO EL. 986.6. HOLE STABILIZED
LOW EL. 986.6.
G DRILL-OUTS BELOW EL. 986.6.
TREMIED CEMENT-BENTONITE GROUT.
89-250M
28-29 AUG 1989
SPT D10 MC LL PL
G.S. 1002.1
SM
SP
SP
SP
SP-SC
SP-SC
ML
976.4
965.9
W.L. 994.0
9
0.17
16
22
10
17
41
150/0.2'
150/0.2'
SAND, M, SILTY, SCATTERED ROOTS, LOOSE, SL. MOIST, DK. BRN., (TOPSOIL)
SAND, M, LOOSE, SL. MOIST-DRY, BRN.
SAND, M, GRAVELLY, MED. DENSE, WET-SAT., BRN.-GR.
SAND, M-C, MED. DENSE, SAT., GR.
SAND, M, CLAYEY, MED. DENSE, WET, BLUE GR.
SAND, M-C, CLAYEY, MED. DENSE, WET, BLUE GR.
SILT, LIMEY, MED. DENSE, WET, SL. WEATHERED ROCK FRAGMENTS, BUFF
TOP OF WEATHERED BEDROCK
SHALEY DOLOMITE: MOD. CALCAREOUS, HARD-SOFT, MOD.-UNCEMENTED, V. WEATHERED, THINLY LAMINATED, BRN.-GR.-WHITE
SANDY DOLOMITE, MOD. CALCAREOUS, HARD, MOD-WELL CEMENTED, OCC. SHALEY INTERBEDS LT. BRN.-GR. (LOGGED FROM CUTTINGS)
1010
1000
990
980
970
960
NOTES:
1. WATER LEVEL DETERMINED AFTER 30 MIN. WITH BOTTOM OF AUGER AT EL. 992.1 AND SAMPLING TO EL. 992.1. CAVE-IN LEVEL &/OR HEAVE MEASURED AT 992.7.
2. SET HOLLOW STEM AUGER TO EL. 989.1. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 989.1.
3. NO WATER LOSS BELOW EL. 989.1.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
SYMBOL
DES
AE APPROVING OFFICIAL:
FLOOD
DESIGNED:
CHECKED:
DRAWN:
ED-D
BORI
ED-GH
DESIGNED: LJL
CHECKED: DC
CAD FILE NAME:
DATE: 05-22-90
SPEC NO: DACW37-
2

89-247M
23 AUG 1989

SPT	D10	MC		LL	PL	

1010

G.S. 1002.1 — SC-SM — SAND, M, CLAYEY, SILTY, MED. STIFF, MOIST, BLK., (TOPSOIL)

1000 — SM — SAND, M, SILTY, LOOSE, DRY, DK. BRN.

SP-SM — SAND, M, LOOSE, SL. MOIST, DK. BRN.

W.L. 993.4 — SP — SAND, M, LOOSE, SAT., BRN.

990 — SP — SAND, F-M, GRAVELLY, LOOSE, SAT., BRN.

SAND, SILTY, F-M, MED. DENSE, SAT., IRON STAINS, BRN.-ORANGE

SM-SP — SAND, M, GRAVELLY, CLAYEY, MED. DENSE, WET, BRN.-ORANGE

980 — SC

976.9 — CL-ML — SILTY CLAY-CLAYEY SILT, GRAVELLY, MED. DENSE, WET, OCC. F-M GRAVEL/WEATHERED ROCK FRAGMENTS, ORANGE

TOP OF WEATHERED BEDROCK

LIMESTONE, DOLOMITIC LIMESTONE, AND SHALE, V. WEATHERED, SANDY, OOLITIC, CALCAREOUS, HARD-SOFT, WELL-UNCEMENTED, YEL.-GR.

970

QUARTZ SANDSTONE SEAM FROM EL. 973.8 TO 973.2

967.0 — DOLOMITE, SANDY, MOD. CALCAREOUS WHEN SCRATCHED, MED. HARD, WELL CEMENTED, SL. WEATHERED, GR. (LOGGED FROM CUTTINGS EL. 972.0 TO EL. 967.0)

960

950

940

SPT	D10	MC	LL	PL
10				
7	0.24			
7				
20	0.07			
16			24	17
150/0.1'				
210/0.4'				
165/0.1'				
155/0.1'				

NOTES:

1. WATER LEVEL DETERMINED AFTER 20 MIN. WITH BOTTOM OF AUGER AT EL. 992.1 AND SAMPLING TO ELEV. 987.1. CAVE-IN LEVEL &/OR HEAVE MEASURED AT 992.5.
2. HOLLOW STEM AUGER SET TO EL. 987.1. HOLE STABILIZED WITH DRILLING MUD BELOW 987.1.
3. WATER LOSS BELOW 987.1 WAS BETWEEN 0 AND 10 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

ND, F-M, SILTY, M. DENSE, DRY, NCRETE SLAB, RUBBLE INTERBEDS, DK. N. (FILL)

AY, GRAVELLY, SANDY, M. STIFF, IST, ORANGE-BRN. (POSSIBLE FILL)

WEATHERED BEDROCK

NE, DOLOMITIC, MOD. CALCAREOUS, EMENTED, F, SL.-UNWEATHERED, SOLID, N., SANDY ZONES, SL. SOFTER BELOW 8, CUTTINGS INDICATE SOME SHALE IN GGED FROM CUTTINGS)

AUGER BELOW EL. 990.3.
BELOW EL. 990.3.

ENT-BENTONITE GROUT.

1010

SAND, M, SILTY, SCATTERED ROOTS, LOOSE, SL. MOIST, DK. BRN., (TOPSOIL)

1000

SAND, M, LOOSE, SL. MOIST-DRY, BRN.

SAND, M, GRAVELLY, MED. DENSE, WET-SAT., BRN.-GR.

SAND, M-C, MED. DENSE, SAT., GR.

990

SAND, M, CLAYEY, MED. DENSE, WET, BLUE GR.

SAND, M-C, CLAYEY, MED. DENSE, WET, BLUE GR.

SILT, LIMEY, MED. DENSE, WET, SL. WEATHERED ROCK FRAGMENTS, BUFF

980

OF WEATHERED BEDROCK

ET DOLOMITE; MOD. CALCAREOUS, HARD-SOFT, -UNCEMENTED, V. WEATHERED, THINLY NATED, BRN.-GR.-WHITE

970

Y DOLOMITE, MOD. CALCAREOUS, HARD, -WELL CEMENTED, OCC. SHALEY INTERBEDS BRN.-GR. (LOGGED FROM CUTTINGS)

960

R 30 MIN. WITH BOTTOM OF
G TO EL. 992.1. CAVE-IN
T 992.7.
L. 989.1. HOLE STABILIZED
89.1.
1.
CEMENT-BENTONITE GROUT.

3

SYMBOL	DESCRIPTION	DATE	APPROVAL

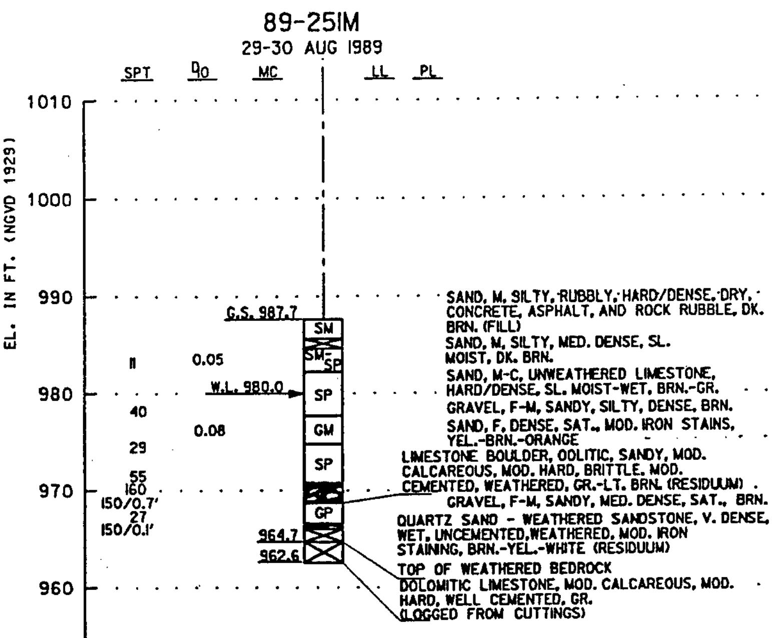
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

BORING LOGS
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
BORING LOGS 89-244M THRU 89-250M

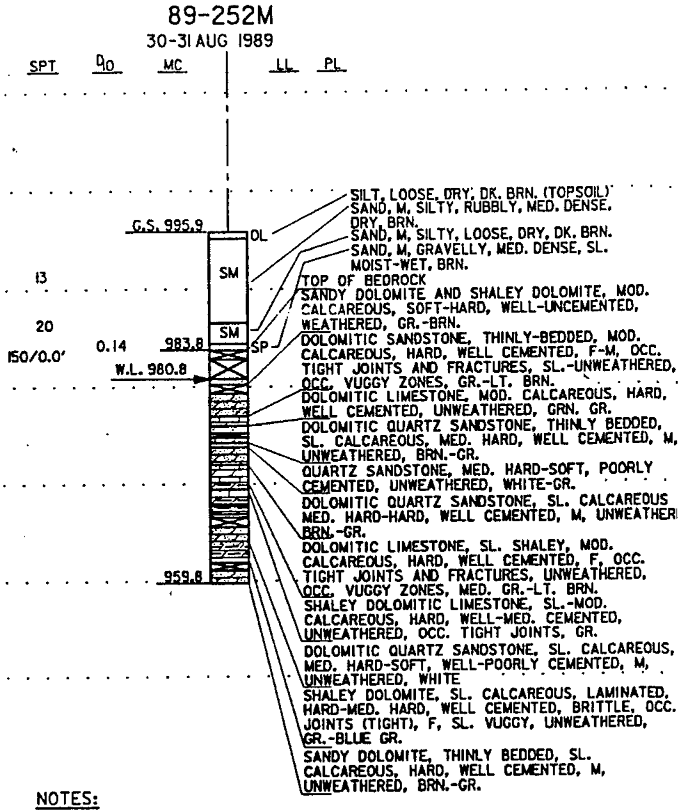
ED-D	DESIGNED:
	CHECKED:
	DRAWN:
ED-GH	DESIGNED: LJL
	CHECKED: DC
DATE: 05-22-90	

CAD FILE NAME: PLATE3.DGN
SPEC NO: DACW37-90-B-0000
DRAWING NUMBER: PLATE C-3
SHT 3 OF 7



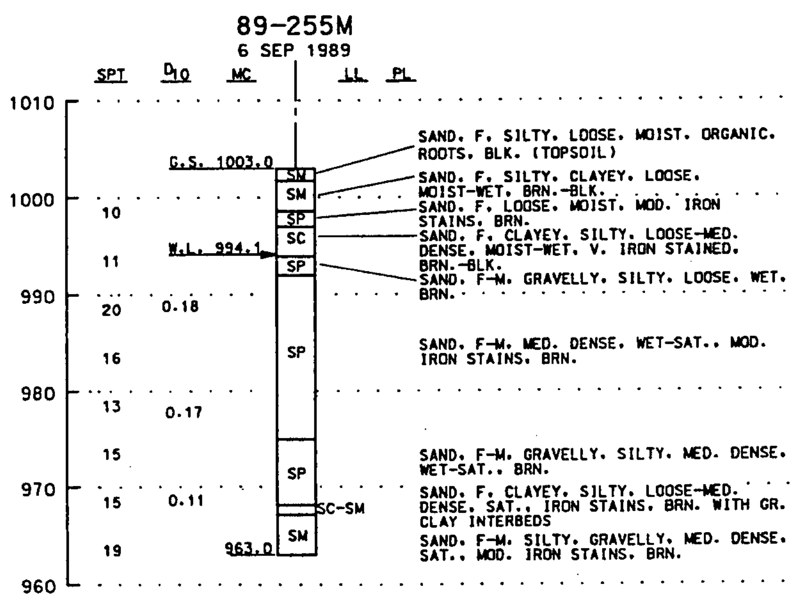
NOTES:

1. WATER LEVEL DETERMINED AFTER 40 MIN. WITH BOTTOM OF AUGER AT EL. 977.7 AND SAMPLING TO EL. 974.0. CAVE-IN LEVEL &/OR HEAVE MEASURED AT 977.5.
2. HOLLOW STEM AUGER INITIALLY SET TO EL. 977.7, LATER RESET TO EL. 968.7 IN ORDER TO STABILIZE THE HOLE. HOLE STABILIZED BELOW EL. 968.7 WITH DRILLING MUD. WATER LOSS BETWEEN 2 AND 5 GPM BELOW EL. 968.7.
3. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



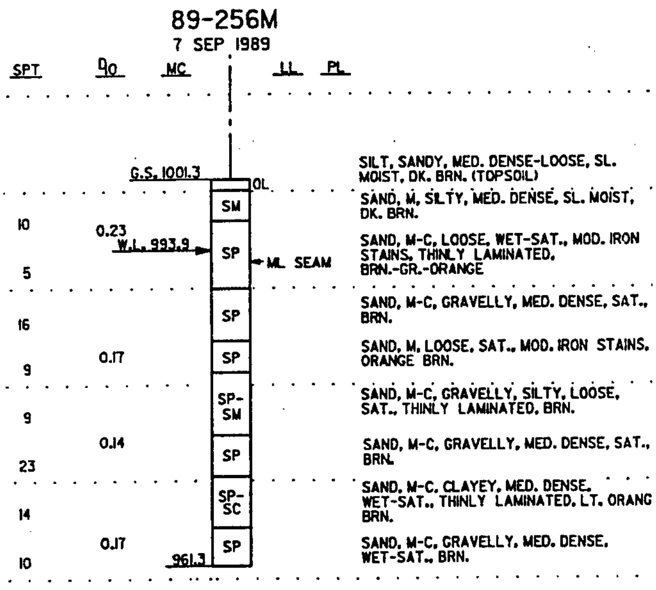
NOTES:

1. WATER LEVEL DETERMINED AFTER 20 MIN. WITH BOTTOM OF AUGER AT EL. 980.9 AND SAMPLING TO EL. 980.3. BOTTOM OF HOLE MEASURED AT EL. 980.3.
2. HOLLOW STEM AUGER SET TO EL. 980.9. 1⅞IN. CORE BARREL USED BELOW 980.3. HOLE STABILIZED WITH DRILLING MUD BELOW 980.3.
3. WATER LOSS DURING CORING OPERATION WAS BETWEEN 0 AND 5 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



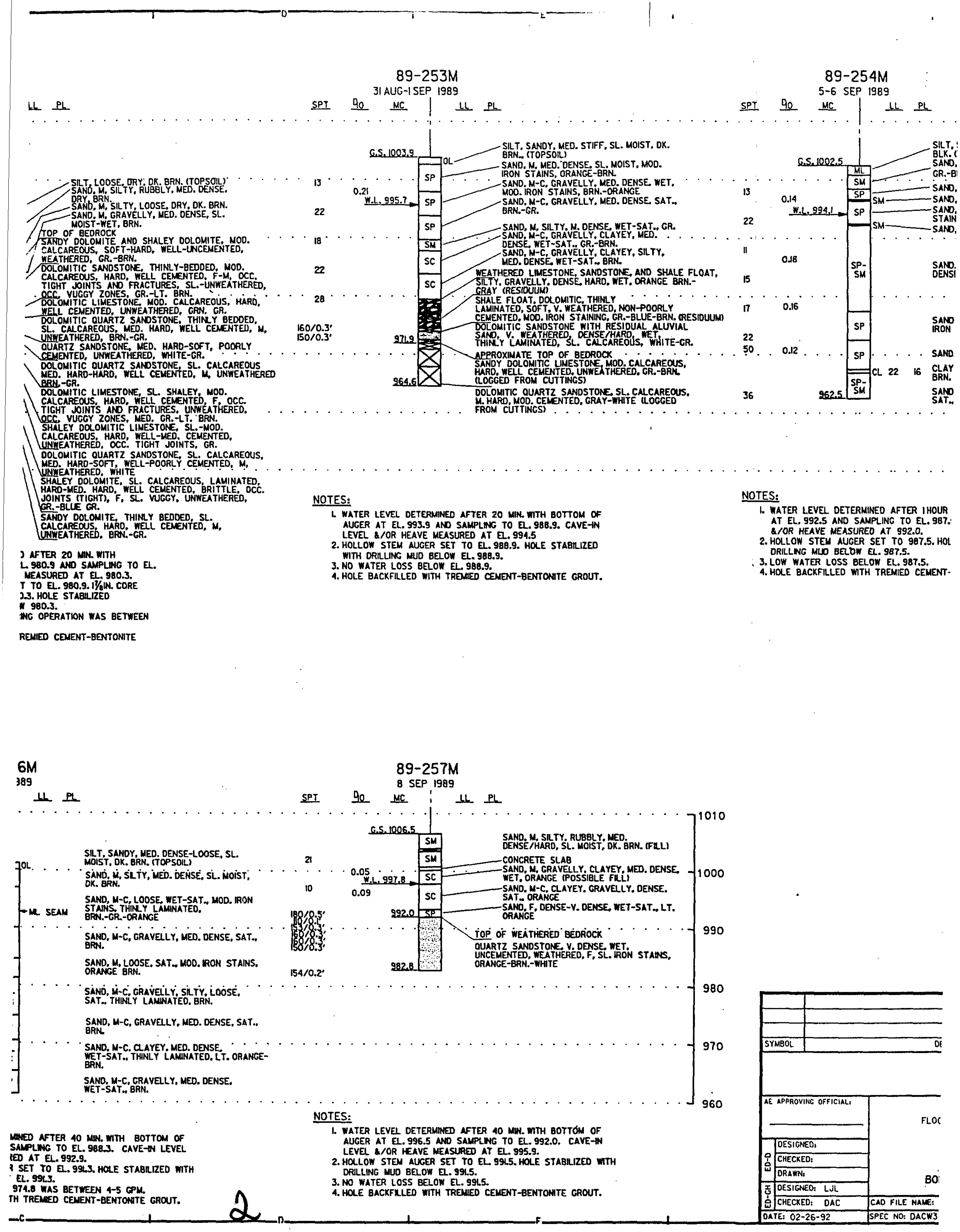
NOTES:

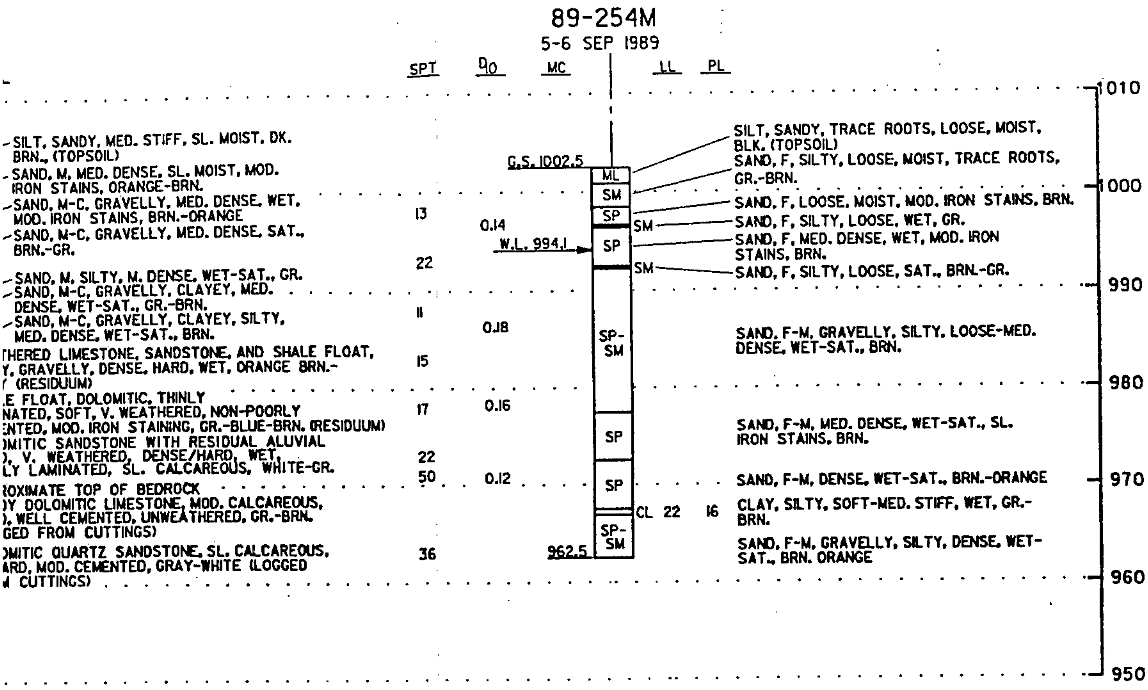
1. WATER LEVEL DETERMINED AFTER 75 MIN. WITH BOTTOM OF AUGER AT EL. 993.0 AND SAMPLING TO EL. 988.0. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 993.3.
2. HOLLOW STEM AUGER SET TO EL. 988.0. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 988.0.
3. LOW WATER LOSS BELOW 988.0.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



NOTES:

1. WATER LEVEL DETERMINED AFTER 40 MIN. WITH BOTTOM OF AUGER AT EL. 991.3 SAMPLING TO EL. 988.3. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 992.9.
2. HOLLOW STEM AUGER SET TO EL. 991.3. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 991.3.
3. WATER LOSS BELOW 974.8 WAS BETWEEN 4-5 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.


89-253M
31 AUG-1 SEP 1989
SPT
MC
LL
PL
G.S. 1003.9
OL
SP
SP
SP
SM
SC
SC
W.L. 995.7
0.21
13
22
18
22
28
160/0.3'
150/0.3'
971.9
964.6
SILT, SANDY, MED. STIFF, SL. MOIST, DK. BRN., (TOPSOIL)
SAND, M, MED. DENSE, SL. MOIST, MOD. IRON STAINS, ORANGE-BRN.
SAND, M-C, GRAVELLY, MED. DENSE, WET, MOD. IRON STAINS, BRN.-ORANGE
SAND, M-C, GRAVELLY, MED. DENSE, SAT., BRN.-GR.
SAND, M, SILTY, M. DENSE, WET-SAT., GR.
SAND, M-C, GRAVELLY, CLAYEY, MED. DENSE, WET-SAT., GR.-BRN.
SAND, M-C, GRAVELLY, CLAYEY, SILTY, MED. DENSE, WET-SAT., BRN.
WEATHERED LIMESTONE, SANDSTONE, AND SHALE FLOAT, SILTY, GRAVELLY, DENSE, HARD, WET, ORANGE BRN.-GRAY (RESIDUUM)
SHALE FLOAT, DOLOMITIC, THINLY LAMINATED, SOFT, V. WEATHERED, NON-POORLY CEMENTED, MOD. IRON STAINING, GR.-BLUE-BRN. (RESIDUUM)
DOLOMITIC SANDSTONE WITH RESIDUAL ALUVIAL SAND, V. WEATHERED, DENSE/HARD, WET, THINLY LAMINATED, SL. CALCAREOUS, WHITE-GR.
APPROXIMATE TOP OF BEDROCK
SANDY DOLOMITIC LIMESTONE, MOD. CALCAREOUS, HARD, WELL CEMENTED, UNWEATHERED, GR.-BRN. (LOGGED FROM CUTTINGS)
DOLOMITIC QUARTZ SANDSTONE, SL. CALCAREOUS, M. HARD, MOD. CEMENTED, GRAY-WHITE (LOGGED FROM CUTTINGS)
LL PL
SILT, LOOSE, DRY, DK. BRN. (TOPSOIL)
SAND, M, SILTY, RUBBLY, MED. DENSE, DRY, BRN.
SAND, M, SILTY, LOOSE, DRY, DK. BRN.
SAND, M, GRAVELLY, MED. DENSE, SL. MOIST-WET, BRN.
TOP OF BEDROCK
SANDY DOLOMITE AND SHALEY DOLOMITE, MOD. CALCAREOUS, SOFT-HARD, WELL-UNCEMENTED, WEATHERED, GR.-BRN.
DOLOMITIC SANDSTONE, THINLY-BEDDED, MOD. CALCAREOUS, HARD, WELL CEMENTED, F-M, OCC. TIGHT JOINTS AND FRACTURES, SL.-UNWEATHERED, OCC. VUGGY ZONES, GR.-LT. BRN.
DOLOMITIC LIMESTONE, MOD. CALCAREOUS, HARD, WELL CEMENTED, UNWEATHERED, GRN. GR.
DOLOMITIC QUARTZ SANDSTONE, THINLY BEDDED, SL. CALCAREOUS, MED. HARD, WELL CEMENTED, M, UNWEATHERED, BRN.-GR.
QUARTZ SANDSTONE, MED. HARD-SOFT, POORLY CEMENTED, UNWEATHERED, WHITE-GR.
DOLOMITIC QUARTZ SANDSTONE, SL. CALCAREOUS MED. HARD-HARD, WELL CEMENTED, M, UNWEATHERED BRN.-GR.
DOLOMITIC LIMESTONE, SL. SHALEY, MOD. CALCAREOUS, HARD, WELL CEMENTED, F, OCC. TIGHT JOINTS AND FRACTURES, UNWEATHERED, OCC. VUGGY ZONES, MED. GR.-LT. BRN.
SHALEY DOLOMITIC LIMESTONE, SL.-MOD. CALCAREOUS, HARD, WELL-MED. CEMENTED, UNWEATHERED, OCC. TIGHT JOINTS, GR.
DOLOMITIC QUARTZ SANDSTONE, SL. CALCAREOUS, MED. HARD-SOFT, WELL-POORLY CEMENTED, M, UNWEATHERED, WHITE
SHALEY DOLOMITE, SL. CALCAREOUS, LAMINATED, HARD-MED. HARD, WELL CEMENTED, BRITTLE, OCC. JOINTS (TIGHT), F, SL. VUGGY, UNWEATHERED, GR.-BLUE GR.
SANDY DOLOMITE, THINLY BEDDED, SL. CALCAREOUS, HARD, WELL CEMENTED, M, UNWEATHERED, BRN.-GR.
) AFTER 20 MIN. WITH
L. 980.9 AND SAMPLING TO EL.
MEASURED AT EL. 980.3.
T TO EL. 980.9. 1 7/8 IN. CORE
).3. HOLE STABILIZED
W 980.3.
ING OPERATION WAS BETWEEN
REMIED CEMENT-BENTONITE
NOTES:
1. WATER LEVEL DETERMINED AFTER 20 MIN. WITH BOTTOM OF AUGER AT EL. 993.9 AND SAMPLING TO EL. 988.9. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 994.5
2. HOLLOW STEM AUGER SET TO EL. 988.9. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 988.9.
3. NO WATER LOSS BELOW EL. 988.9.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
89-254M
5-6 SEP 1989
SPT
MC
LL
PL
G.S. 1002.5
ML
SM
SP
SP
SM
SM
SP-SM
SP
SP
SP-SM
CL 22 16
W.L. 994.1
0.14
0.18
0.16
0.12
13
22
11
15
17
22
50
36
962.5
SILT,
BLK.
SAND,
GR.-B
SAND,
SAND,
SAND,
STAIN
SAND,
SAND,
DENSI
SAND
IRON
SAND
CLAY
BRN.
SAND
SAT.,
NOTES:
1. WATER LEVEL DETERMINED AFTER 1 HOUR AT EL. 992.5 AND SAMPLING TO EL. 987. &/OR HEAVE MEASURED AT 992.0.
2. HOLLOW STEM AUGER SET TO 987.5. HOL DRILLING MUD BELOW EL. 987.5.
3. LOW WATER LOSS BELOW EL. 987.5.
4. HOLE BACKFILLED WITH TREMIED CEMENT-
6M
389
LL PL
OL
ML SEAM
SILT, SANDY, MED. DENSE-LOOSE, SL. MOIST, DK. BRN. (TOPSOIL)
SAND, M, SILTY, MED. DENSE, SL. MOIST, DK. BRN.
SAND, M-C, LOOSE, WET-SAT., MOD. IRON STAINS, THINLY LAMINATED, BRN.-GR.-ORANGE
SAND, M-C, GRAVELLY, MED. DENSE, SAT., BRN.
SAND, M, LOOSE, SAT., MOD. IRON STAINS, ORANGE BRN.
SAND, M-C, GRAVELLY, SILTY, LOOSE, SAT., THINLY LAMINATED, BRN.
SAND, M-C, GRAVELLY, MED. DENSE, SAT., BRN.
SAND, M-C, CLAYEY, MED. DENSE, WET-SAT., THINLY LAMINATED, LT. ORANGE-BRN.
SAND, M-C, GRAVELLY, MED. DENSE, WET-SAT., BRN.
MINED AFTER 40 MIN. WITH BOTTOM OF
SAMPLING TO EL. 988.3. CAVE-IN LEVEL
RED AT EL. 992.9.
R SET TO EL. 991.3. HOLE STABILIZED WITH
EL. 991.3.
974.8 WAS BETWEEN 4-5 GPM.
TH TREMIED CEMENT-BENTONITE GROUT.
89-257M
8 SEP 1989
SPT
MC
LL
PL
G.S. 1006.5
SM
SM
SC
SC
SP
W.L. 997.8
0.05
0.09
21
10
180/0.5'
154/0.2'
992.0
982.8
SAND, M, SILTY, RUBBLY, MED. DENSE/HARD, SL. MOIST, DK. BRN. (FILL)
CONCRETE SLAB
SAND, M, GRAVELLY, CLAYEY, MED. DENSE, WET, ORANGE (POSSIBLE FILL)
SAND, M-C, CLAYEY, GRAVELLY, DENSE, SAT., ORANGE
SAND, F, DENSE-V. DENSE, WET-SAT., LT. ORANGE
TOP OF WEATHERED BEDROCK
QUARTZ SANDSTONE, V. DENSE, WET, UNCEMENTED, WEATHERED, F, SL. IRON STAINS, ORANGE-BRN.-WHITE
1010
1000
990
980
970
960
NOTES:
1. WATER LEVEL DETERMINED AFTER 40 MIN. WITH BOTTOM OF AUGER AT EL. 996.5 AND SAMPLING TO EL. 992.0. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 995.9.
2. HOLLOW STEM AUGER SET TO EL. 991.5. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 991.5.
3. NO WATER LOSS BELOW EL. 991.5.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.
SYMBOL
AE APPROVING OFFICIAL:
FLO
ED-D DESIGNED:
CHECKED:
DRAWN:
BO
ED-GH DESIGNED: LJL
CHECKED: DAC
CAD FILE NAME:
DATE: 02-26-92
SPEC NO: DACW3
2

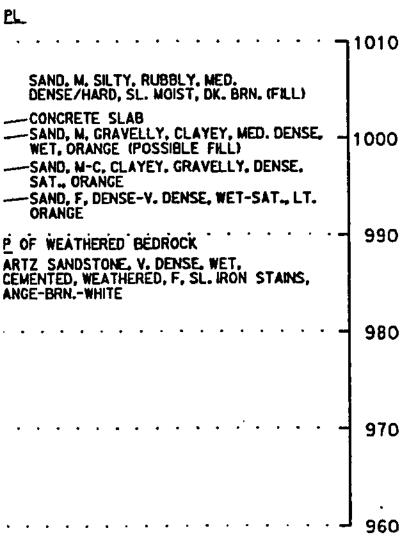


20 MIN. WITH BOTTOM OF
G TO EL. 988.9. CAVE-IN
EL. 994.5
988.9. HOLE STABILIZED
L9.

EMENT-BENTONITE GROUT.

NOTES:

1. WATER LEVEL DETERMINED AFTER 1HOUR WITH BOTTOM OF AUGER AT EL. 992.5 AND SAMPLING TO EL. 987.5. CAVE-IN LEVEL &/OR HEAVE MEASURED AT 992.0.
2. HOLLOW STEM AUGER SET TO 987.5. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 987.5.
3. LOW WATER LOSS BELOW EL. 987.5.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



R 40 MIN. WITH BOTTOM OF
ING TO EL. 992.0. CAVE-IN
AT EL. 995.9.
L. 991.5. HOLE STABILIZED WITH
5.
CEMENT-BENTONITE GROUT.

3

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

ED-D: DESIGNED: / CHECKED: / DRAWN:

ED-GH: DESIGNED: LJL / CHECKED: DAC

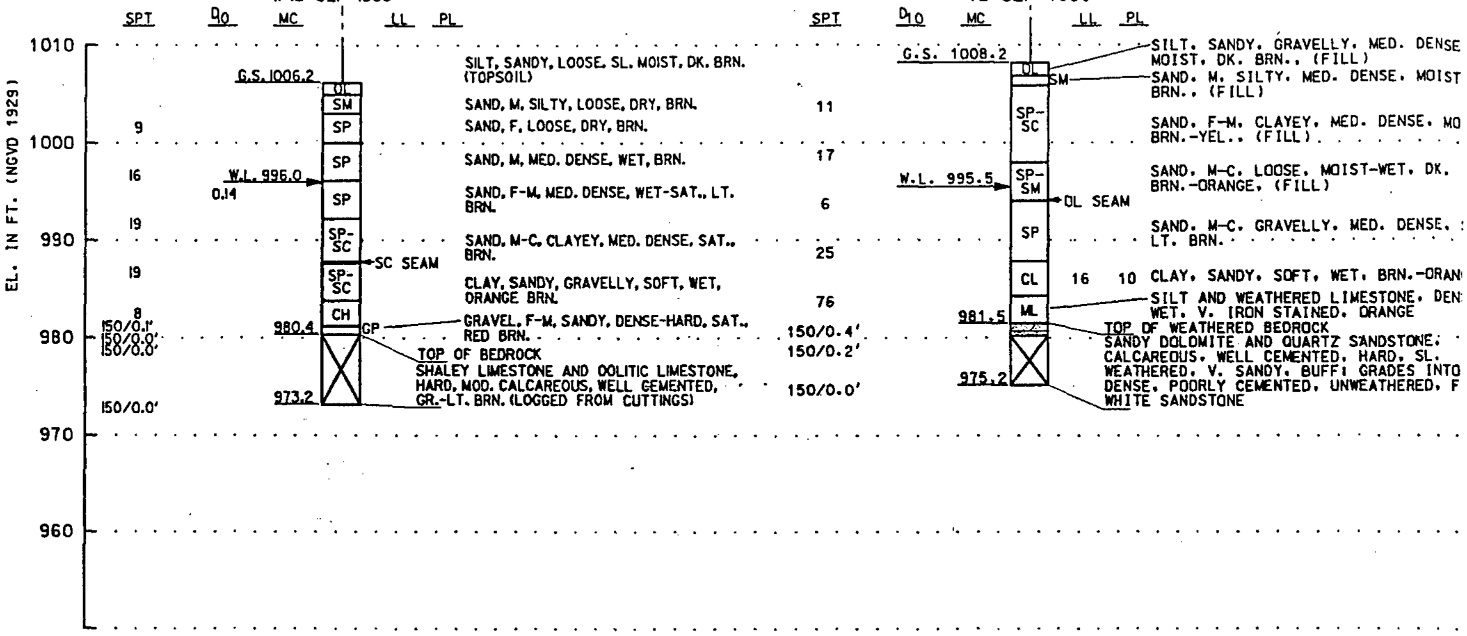
DATE: 02-26-92

BORING LOGS
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
BORING LOGS 89-251M THRU 89-257M

CAD FILE NAME: PLATE4.DGN
SPEC NO: DACW37-90-B-0000
DRAWING NUMBER: PLATE C-4
SHT 4 OF 7

89-258M
II-12 SEP 1989

89-259M
12 SEP 1989

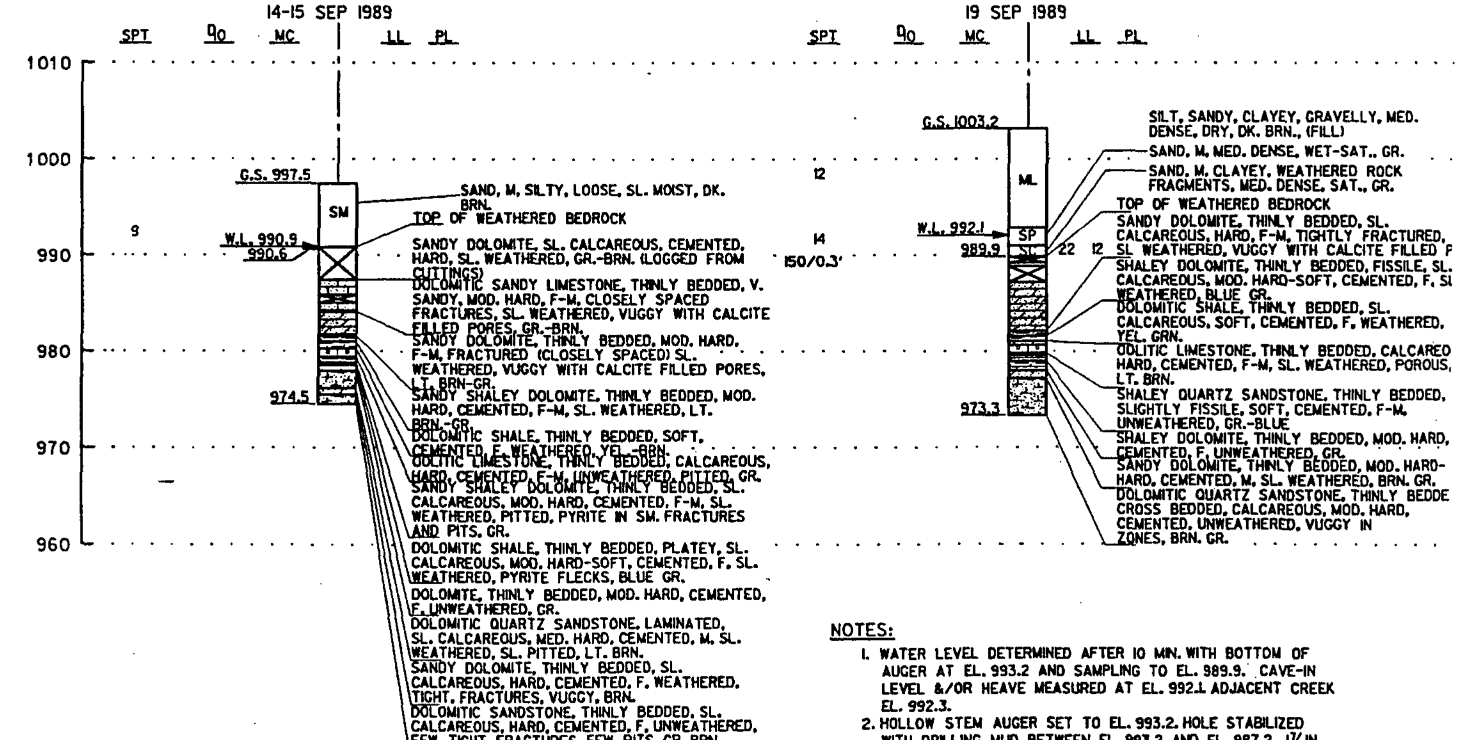


NOTES:
1. WATER LEVEL DETERMINED AFTER 13 HOURS WITH BOTTOM OF AUGER AT EL. 991.2 AND SAMPLING TO EL. 991.2. CAVE-IN LEVEL &/OR HEAVE MEAURED AT EL. 992.6.
2. HOLLOW STEM AUGER SET TO EL. 991.2. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 991.2.
3. NO WATER LOSS BETWEEN EL. 991.2 AND EL. 973.2.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

NOTES:
1. WATER LEVEL DETERMINED AFTER 30 MIN. WITH BOTTOM OF AUGER AT EL. 993.2. SAMPLING TO EL. 988.2. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 994.4. ADJCENT CREEK EL. 995.4.
2. HOLLOW STEM AUGER SET TO EL. 993.2. STABILIZED HOLE WITH DRILLING MUD BELOW 995.4.
3. NO WATER LOSS BELOW EL. 993.2.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

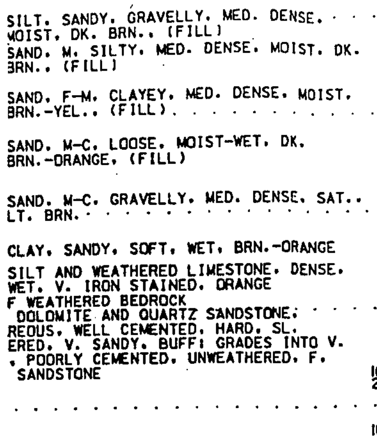
89-262M
14-15 SEP 1989

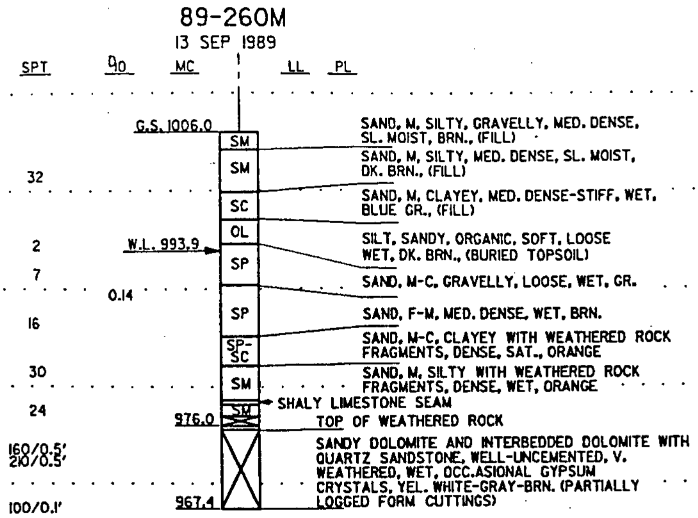
89-263M
19 SEP 1989

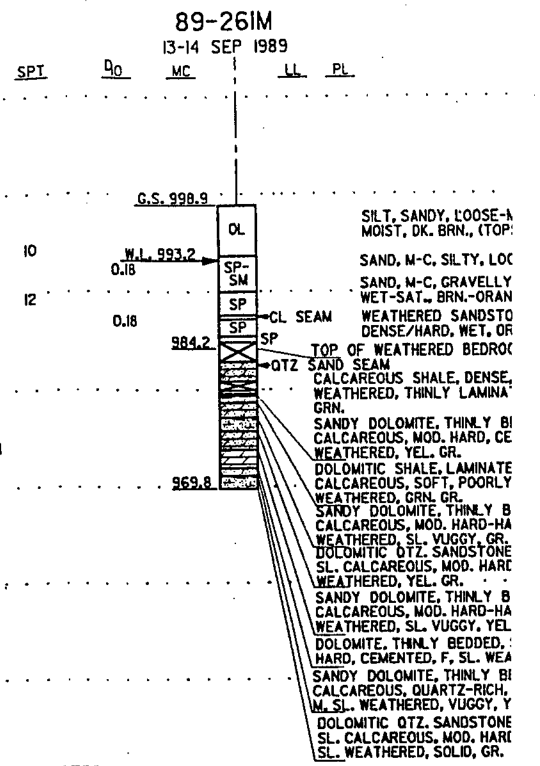


NOTES:
1. WATER LEVEL DETERMINED AFTER 13 HOURS WITH BOTTOM OF AUGER AT EL. 992.5 AND SAMPLING TO EL. 990.4. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 990.8 DURING WATER LEVEL MEASUREMENTS AND THEN TO 992.5 OVERNIGHT. ADJACENT CREEK EL. 991.5.
2. HOLLOW STEM AUGER SET TO EL. 992.5. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 992.5. 1⅞IN. CORE BARREL USED BELOW EL. 987.4.
3. NO WATER LOSS BELOW EL. 992.5.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

NOTES:
1. WATER LEVEL DETERMINED AFTER 10 MIN. WITH BOTTOM OF AUGER AT EL. 993.2 AND SAMPLING TO EL. 989.9. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 992.1 ADJACENT CREEK EL. 992.3.
2. HOLLOW STEM AUGER SET TO EL. 993.2. HOLE STABILIZED WITH DRILLING MUD BETWEEN EL. 993.2 AND EL. 987.2. 1⅞IN. CORE BARREL USED BELOW EL. 987.2.
3. NO WATER LOSS BELOW EL. 993.2.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.







R 30 MIN. WITH BOTTOM OF
G TO EL. 988.2. CAVE-IN
.T EL. 994.4. ADJCENT CREEK EL.

. 993.2. STABILIZED HOLE WITH

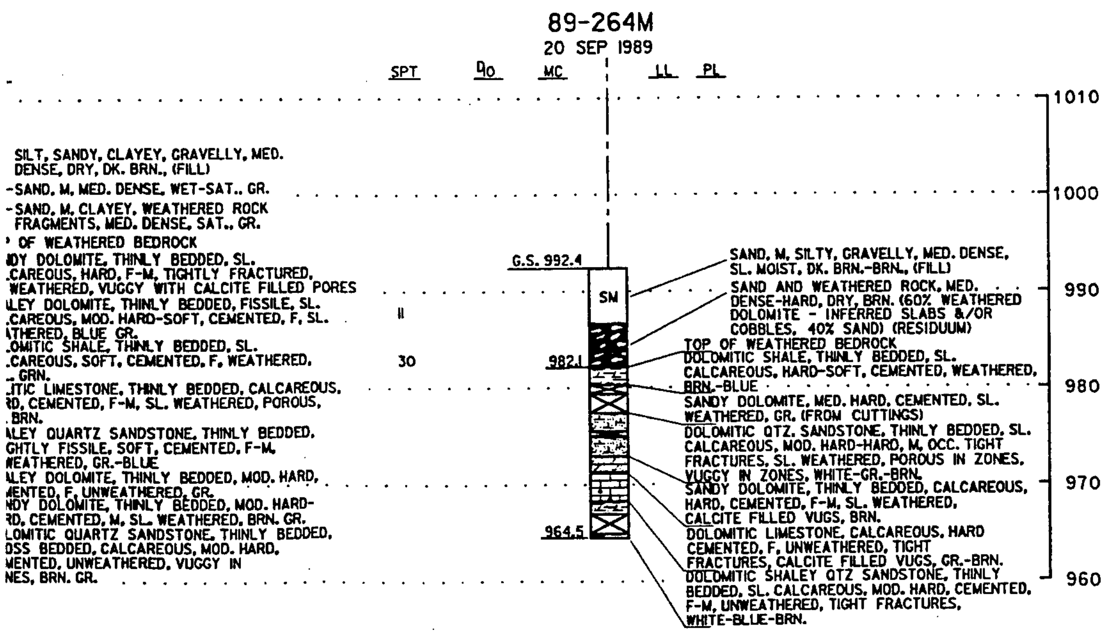
.2.
D CEMENT-BENTONITE GROUT.

NOTES:

1. WATER LEVEL DETERMINED AFTER 20 MIN. WITH BOTTOM OF AUGER AT EL. 991.0 AND SAMPLING TO EL. 988.0. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 992.5. ADJACENT CREEK EL. 995.4.
2. HOLLOW STEM AUGER SET TO EL. 991.0. HOLE STABILIZED WITH DRILLING MUD BELOW 991.0.
3. WATER LOSS BELOW EL. 973.0 WAS BETWEEN 2 AND 3 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

NOTES:

1. WATER LEVEL DETERMINED AFTER 13 HOURS WITH BOTTO AUGER AT EL. 988.9 AND SAMPLING TO EL. 984.9. CAVE LEVEL &/OR HEAVE MEASURED AT EL. 990.1. ADJACENT EL. 992.7.
2. HOLLOW STEM AUGER SET TO EL. 988.9. HOLE STABILIZE WITH DRILLING MUD BELOW EL. 988.9. 1⅞IN. CORE BARREL BELOW EL. 979.4.
3. NO WATER LOSS BELOW EL. 988.9.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GRO



IO MIN. WITH BOTTOM OF
3 TO EL. 989.9. CAVE-IN
EL. 992.1 ADJACENT CREEK

993.2. HOLE STABILIZED
93.2 AND EL. 987.2. 1⅞IN.
7.2.

EMENT-BENTONITE GROUT.

NOTES:

1. WATER LEVEL NOT ENCOUNTERED. ADJACENT CREEK AT EL. 980.0.
2. HOLLOW STEM AUGER SET TO EL. 982.4. HOLE STABLIZED WITH DRILLING MUD BELOW EL. 982.4. 1⅞IN. CORE BARREL USED BELOW EL. 980.3.
3. WATER LOSS 4-5 GPM BETWEEN EL. 977.4-972.4. WATER LOSS 4-5 GPM BETWEEN EL. 967.5-964.5.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

SYMBOL	DESCRIPTION

AE APPROVING OFFICIAL:

FLOOD CONTROL
ROCHE
STAGE
BORING LOGS

ED-D	DESIGNED:	
	CHECKED:	
	DRAWN:	
ED-GH	DESIGNED: LJL	
	CHECKED: DAC	CAD FILE NAME: PLATES.DG
DATE: 02-26-92		SPEC NO: DACW37-90-B-000

2

:Y, MED. DENSE.
ISE, SL. MOIST,
IENSE-STIFF, WET,
OFT, LOOSE
TOPSOIL)
OOSE, WET, GR.
WET, BRN.
H WEATHERED ROCK
., ORANGE
ATHERED ROCK
, ORANGE
EDDED DOLOMITE WITH
ICEMENTED, V.
. GYPSUM
BRN. (PARTIALLY

REEK
WITH
M.

89-261M

13-14 SEP 1989

SPT | %o | MC | LL | PL

1010
1000
990
980
970
960

G.S. 998.9

W.L. 993.2

10

0.18

12

0.18

984.2

969.8

OL

SP-SM

SP

SP

CL SEAM

SP

QTZ SAND SEAM

SILT, SANDY, LOOSE-MED. DENSE, SL. MOIST, DK. BRN., (TOPSOIL)

SAND, M-C, SILTY, LOOSE, WET, GR.

SAND, M-C, GRAVELLY, MED. DENSE, WET-SAT., BRN.-ORANGE

WEATHERED SANDSTONE AND SAND, M, DENSE/HARD, WET, ORANGE

TOP OF WEATHERED BEDROCK

CALCAREOUS SHALE, DENSE, WET, UNCEMENTED, WEATHERED, THINLY LAMINATED, BRN.-YEL.-YEL. GRN.

SANDY DOLOMITE, THINLY BEDDED, SL. CALCAREOUS, MOD. HARD, CEMENTED, F, SL. WEATHERED, YEL. GR.

DOLOMITIC SHALE, LAMINATED, CLAYEY, CALCAREOUS, SOFT, POORLY CEMENTED, F, WEATHERED, GRN. GR.

SANDY DOLOMITE, THINLY BEDDED, SL. CALCAREOUS, MOD. HARD-HARD, CEMENTED, F, SL. WEATHERED, SL. VUGGY, GR.

DOLOMITIC QTZ. SANDSTONE, THINLY BEDDED, SL. CALCAREOUS, MOD. HARD, CEMENTED, M, WEATHERED, YEL. GR.

SANDY DOLOMITE, THINLY BEDDED, SL. CALCAREOUS, MOD. HARD-HARD, CEMENTED, WEATHERED, SL. VUGGY, YEL.-GR.

DOLOMITE, THINLY BEDDED, SL. CALCAREOUS, HARD, CEMENTED, F, SL. WEATHERED, GR.

SANDY DOLOMITE, THINLY BEDDED, SL. CALCAREOUS, QUARTZ-RICH, MOD. HARD, CEMENTED, M. SL. WEATHERED, VUGGY, YEL. GR.

DOLOMITIC QTZ. SANDSTONE, THINLY BEDDED, SL. CALCAREOUS, MOD. HARD, CEMENTED, M, SL. WEATHERED, SOLID, GR.

NOTES:

1. WATER LEVEL DETERMINED AFTER 13 HOURS WITH BOTTOM OF AUGER AT EL. 988.9 AND SAMPLING TO EL. 984.9. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 990.1. ADJACENT CREEK EL. 992.7.
2. HOLLOW STEM AUGER SET TO EL. 988.9. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 988.9. 1⅞IN. CORE BARREL USED BELOW EL. 979.4.
3. NO WATER LOSS BELOW EL. 988.9.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

1010
1000
990
980
970
960

LLY, MED. DENSE,
N., (FILL)
) ROCK, MED.
(60% WEATHERED
) SLABS &/OR
(RESIDUUM)
K
DDED, SL.
MENTED, WEATHERED,
, CEMENTED, SL.
INGS)
THINLY BEDDED, SL.
D, M, OCC. TIGHT
POROUS IN ZONES.
-BRN.
DDED, CALCAREOUS,
EATHERED,
AREOUS, HARD
, TIGHT
VUGS, GR.-BRN.
DSTONE, THINLY
DD. HARD, CEMENTED,
RACTURES,

EL.
) WITH
BELOW
JT.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

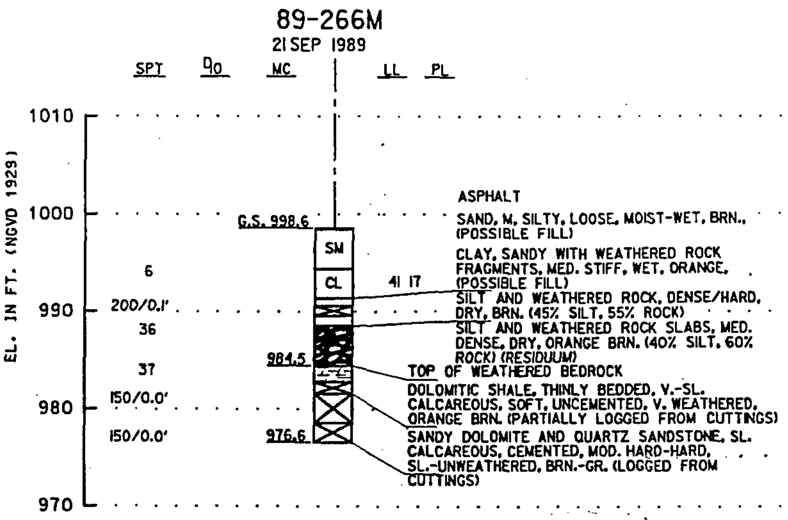
BORING LOGS
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
BORING LOGS 89-258M THRU 89-264M

ED-D: DESIGNED: / CHECKED: / DRAWN:
ED-GH: DESIGNED: LJL / CHECKED: DAC
DATE: 02-26-92

CAD FILE NAME: PLATE5.DGN
SPEC NO: DACW37-90-B-0000

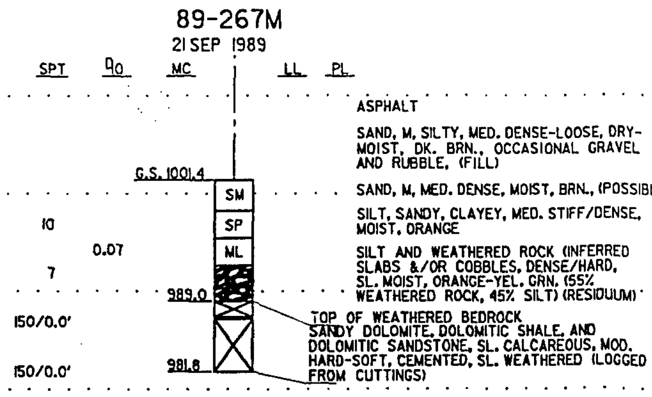
DRAWING NUMBER: PLATE C-5

SHT 5 OF 7



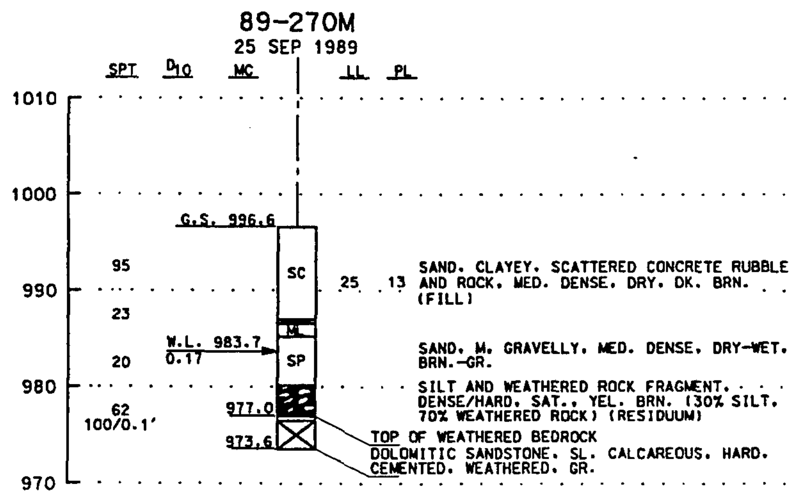
NOTES:

1. WATER LEVEL NOT ENCOUNTERED. ADJACENT CREEK EL. 984.4.
2. HOLLOW STEM AUGER SET TO EL. 983.6. HOLE DRILLED AND STABILIZED WITH DRILLING MUD BELOW EL. 983.6
3. NO WATER LOSS BELOW EL. 983.6.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



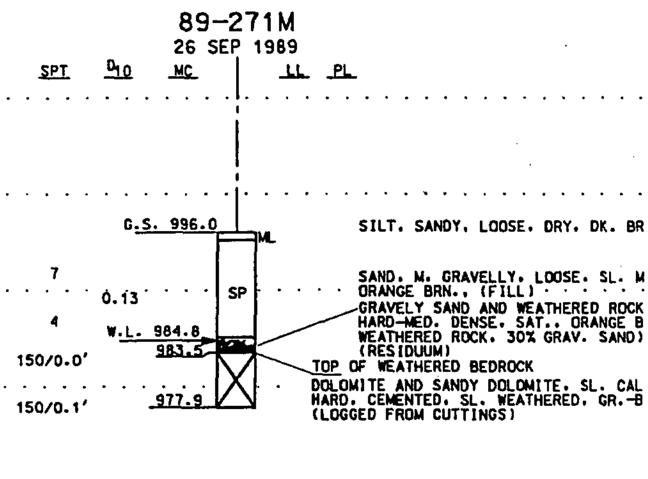
NOTES:

1. WATER LEVEL NOT ENCOUNTERED. ADJACENT CREEK EL. 984.4
2. HOLLOW STEM AUGER SET TO EL. 991.4. HOLE DRILLED AND STABILIZED BELOW EL. 991.4 WITH DRILLING MUD.
3. NO WATER LOSS BELOW EL. 991.4.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



NOTES:

1. WATER LEVEL DETERMINED AFTER 15 MIN. WITH BOTTOM OF AUGER AT EL. 981.6 AND SAMPLING TO EL. 976.6. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 981.7.
2. HOLLOW STEM AUGER SET TO EL. 981.6. DRILLING MUD USED TO STABILIZE HOLE BELOW EL. 981.6.
3. 100% WATER LOSS BELOW EL. 981.6 (NO WATER RETURN).
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.



NOTES:

1. WATER LEVEL DETERMINED AFTER 15 MIN. WITH BOTTOM OF AUGER AT EL. 986.0 AND SAMPLING TO EL. 983.5. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 984.5. ADJACENT CREEK EL. 984.3.
2. HOLLOW STEM AUGER SET TO EL. 986.0. HOLE STABILIZED WIT DRILLING MUD BELOW EL. 986.0.
3. NO WATER LOSS BELOW EL. 986.0.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

PL

ASPHALT

SAND, M, SILTY, MED. DENSE-LOOSE, DRY-MOIST, DK. BRN., OCCASIONAL GRAVEL AND RUBBLE, (FILL)

SAND, M, MED. DENSE, MOIST, BRN., (POSSIBLE FILL)

SILT, SANDY, CLAYEY, MED. STIFF/DENSE, MOIST, ORANGE

SILT AND WEATHERED ROCK (INFERRED SLABS &/OR COBBLES, DENSE/HARD, SL. MOIST, ORANGE-YEL. GRN. (55% WEATHERED ROCK, 45% SILT) (RESIDUUM)

TOP OF WEATHERED BEDROCK

SANDY DOLOMITE, DOLOMITIC SHALE, AND DOLOMITIC SANDSTONE, SL. CALCAREOUS, MOD. HARD-SOFT, CEMENTED, SL. WEATHERED (LOGGED FROM CUTTINGS)

ERED. ADJACENT CREEK EL. 984.4
TO EL. 99I.4. HOLE DRILLED AND
WITH DRILLING MUD.
99I.4.
MIED CEMENT-BENTONITE GROUT.

89-268M

22 SEP 1989

SPT D_{10} MC LL PL

G.S. 1002.6

34 SM

8

150/0.1' 991.7

TOP OF WEATHERED BEDROCK

150/0.0' 984.6

SAND, M, SILTY, CONCRETE SLABS - REBAR & ROCK FRAGMENTS, MED. DENSE, DRY, DK. BRN., (FILL)

DOLOMITE, SL. CALCAREOUS, HARD, CEMENTED, SL. WEATHERED, GR. (LOGGED FROM CUTTINGS)

NOTES:

1. WATER LEVEL NOT ENCOUNTERED. ADJACENT CREEK EL. 990.6.
2. HOLLOW STEM AUGER SET TO EL. 992.6. HOLE DRILLED AND STABILIZED WITH DRILLING MUD BELOW EL. 992.6.
3. WATER LOSS BELOW EL. 989.6 WAS BETWEEN 8 AND 9 GPM. DRILLING BIT 'DROPPED' A FEW INCHES AT EL. 989.6. SMOOTH, HARD DRILL-OUT BELOW EL. 989.6.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

89-269M

23 SEP 1989

SPT D_{10} MC LL PL

G.S. 994.8 SM

150/0.0' W.L. 990.7 990.4 SC

150/0.0' 984.8

SAND, M, LOOSE, SL

SAND, M, BRN.-GR.

TOP OF WEATHER

SANDY DOLOMITE CEMENTED, SL. FROM CUTTINGS)

NOTES:

1. WATER LEVEL DETERMINED AFTER 15 MI AUGER AT EL. 990.3 AND SAMPLING TO HOLE MEASURED AT EL. 990.3
2. HOLLOW STEM AUGER SET TO EL. 990.3 DRILLED BELOW EL. 990.3 WITH DRILL
3. NO WATER LOSS BELOW EL. 990.3.
4. HOLE BACKFILLED WITH TREMIED CEMEN

9

LL PL

SILT, SANDY, LOOSE, DRY, DK. BRN.

SAND, M, GRAVELLY, LOOSE, SL. MOIST, ORANGE BRN., (FILL)

GRAVELY SAND AND WEATHERED ROCK, HARD-MED. DENSE, SAT., ORANGE BRN. (70% WEATHERED ROCK, 30% GRAV. SAND) (RESIDUUM)

TOP OF WEATHERED BEDROCK

DOLOMITE AND SANDY DOLOMITE, SL. CALCAREOUS, HARD, CEMENTED, SL. WEATHERED, GR.-BRN. (LOGGED FROM CUTTINGS)

IINED AFTER 15 MIN. WITH BOTTOM OF
AND SAMPLING TO EL. 983.5. CAVE-IN
EASURED AT EL. 984.5. ADJACENT CREEK

SET TO EL. 986.0. HOLE STABILIZED WITH
EL. 986.0.
W EL. 986.0.
TH TREMIED CEMENT-BENTONITE GROUT.

89-272M

27 SEP 1989

SPT D_{10} MC LL PL

G.S. 1009.3

10 ML

0.20

15 SP

W.L. 998.2 SP

13 SC 993.1

85

983.2

SILT, SANDY, MED. DENSE, DRY, DK. BRN., (TOPSOIL), (POSSIBLE FILL)

SAND, M, GRAVELLY, MED. DENSE, DRY, LT. BRN., (POSSIBLE FILL)

SAND, F-M, MED. DENSE, SAT., BRN.

SAND, M, CLAYEY, GRAVELLY, MED. DENSE, ORANGE-BRN.

TOP OF WEATHERED BEDROCK

QUARTZ SANDSTONE, DENSE, UNCEMENTED, WEATHERED, MOD. IRON STAIN, WET, F, WHITE-BRN., V.- SL. SHALEY ZONES

NOTES:

1. WATER LEVEL DETERMINED AFTER 20 MIN. WITH BOTTOM OF AUGER AT EL. 994.3 AND SAMPLING TO EL. 989.3. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 994.8
2. HOLLOW STEM AUGER SET TO EL. 994.3. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 994.3.
3. WATER LOSS BELOW EL. 994.3 WAS BETWEEN 2 AND 3 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

89-273M

27 SEP 1989

SPT D_{10} MC LL PL

G.S. 1010.7 ML

13 SP

0.21 SP

7 W.L. 1000.0 SP

7 CH

CL 44 19

1

8 CL 38 15

4

22 SP

150/0.3' 981.8 SP-SC

126/0.4'

150/0.0' 975.7

SILT, SANDY

SAND, M, LC

SAND, M-C, MOIST, BRN.

SAND, M-C,

CLAY, SANDY

CLAY, MED.

CLAY, SANDY ZONE AT EL. SAT. ORANGE

SAND, M-C,

SAND, M-C, ORANGE

TOP OF WEATHERE

QUARTZ SANDSTONI WEATHERED, MOD. YEL.-WHITE-ORAN

NOTES:

1. WATER LEVEL DETERMINED AFTER 30 MIN. AUGER AT EL. 995.7 AND SAMPLING TO E LEVEL &/OR HEAVE MEASURED AT EL. 99
2. HOLLOW STEM AUGER SET TO EL. 992.7. DRILLING MUD BELOW 992.7.
3. WATER LOSS BELOW EL. 980.7 WAS BETW
4. ONE 3 IN. UNDISTURBED SAMPLE TAKEN 990.7 IN THE PILOT HOLE.
5. HOLE BACKFILLED WITH TREMIED CEMENT-

SYMBOL	DESCRIP

AE APPROVING OFFICIAL:	FLOOD CO
ED-D DESIGNED:	S
ED-D CHECKED:	
ED-D DRAWN:	BORING
ED-GH DESIGNED: LJL	
ED-GH CHECKED: DAC	CAD FILE NAME: PLA
DATE: 02-26-92	SPEC NO: DACW37-90-

89-269M
23 SEP 1989

SPT D_{10} MC LL PL

1010

1000

ND. M. SILTY. CONCRETE SLABS -
BAR & ROCK FRAGMENTS. MED. DENSE.
.Y. DK. BRN., (FILL)

WEATHERED BEDROCK

E. SL. CALCAREOUS. HARD. CEMENTED.
.THERED. GR. (LOGGED FROM CUTTINGS)

G.S. 994.8 — SM — SAND. M. SILTY.SCATTERED PLANT MATTER. LOOSE. SL. MOIST. DK. BRN.

150/0.0' W.L. 990.7 — 990.4 — SC — SAND. M. CLAYEY. LOOSE. SAT.. DK. BRN.-GR.

TOP OF WEATHERED BEDROCK

150/0.0' 984.8 — SANDY DOLOMITE. SL. CALCAREOUS. HARD. CEMENTED. SL. WEATHERED. GR.-BRN. (LOGGED FROM CUTTINGS)

990

980

970

ADJACENT CREEK EL. 990.6.
992.6. HOLE DRILLED AND
BELOW EL. 992.6.
IS BETWEEN 8 AND 9 GPM.
INCHES AT EL. 989.6. SMOOTH.
.6.
CEMENT-BENTONITE GROUT.

NOTES:

1. WATER LEVEL DETERMINED AFTER 15 MIN. WITH BOTTOM OF AUGER AT EL. 990.3 AND SAMPLING TO EL. 990.4. BOTTOM OF HOLE MEASURED AT EL. 990.3
2. HOLLOW STEM AUGER SET TO EL. 990.3. HOLE STABILIZED AND DRILLED BELOW EL. 990.3 WITH DRILLING MUD.
3. NO WATER LOSS BELOW EL. 990.3.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

89-273M
27 SEP 1989

SPT D_{10} MC LL PL

G.S. 1010.7 — ML — SILT. SANDY. LOOSE. DRY. DK. BRN. — 1010

SILT, SANDY, MED. DENSE, DRY, DK. BRN., TOPSOIL), (POSSIBLE FILL)

13 — SP — SAND. M. LOOSE. DRY. BRN.

0.21 — SP — SAND. M-C. GRAVELLY. LOOSE. DRY-SL. MOIST. BRN.

SAND, M, GRAVELLY, MED. DENSE, DRY, LT. BRN., (POSSIBLE FILL)

7 — W.L. 1000.0 — SP — SAND. M-C. GRAVELLY. LOOSE. WET. BRN. — 1000

SAND, F-M, MED. DENSE, SAT., BRN.

SAND, M, CLAYEY, GRAVELLY, MED. DENSE, ORANGE-BRN.

7 — CH — CLAY. SANDY. SOFT. WET. YEL. BRN.

CL — 44 19 — CLAY. MED. STIFF. WET. ORANGE-GR.

WEATHERED BEDROCK

8 4 — CL — 38 15 — CLAY. SANDY. MED. STIFF - SOFT ZONE AT EL. 988.6 TO 987.6. WET - SAT. ORANGE-BRN.-GR. — 990

Z SANDSTONE, DENSE, UNCEMENTED, ERED, MOD. IRON STAIN, WET, F, BRN., V.- SL. SHALEY ZONES

22 — SP — SAND. M-C. MED. DENSE. SAT.. BRN.

150/0.3' — 981.8 — SP-SC — SAND. M-C. CLAYEY. MED. DENSE. SAT.. ORANGE

126/0.4' — TOP OF WEATHERED BEDROCK — 980

150/0.0' — 975.7 — QUARTZ SANDSTONE. UNCEMENTED. WEATHERED. MOD. IRON STAINING. WET. F. YEL.-WHITE-ORANGE

970

) MIN. WITH BOTTOM OF
TO EL. 989.3. CAVE-IN
EL. 994.8
94.3. HOLE STABILIZED WITH

BETWEEN 2 AND 3 GPM.
IENT-BENTONITE GROUT.

NOTES:

1. WATER LEVEL DETERMINED AFTER 30 MIN. WITH BOTTOM OF AUGER AT EL. 995.7 AND SAMPLING TO EL. 992.7. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 997.2.
2. HOLLOW STEM AUGER SET TO EL. 992.7. HOLE STABILIZED WITH DRILLING MUD BELOW 992.7.
3. WATER LOSS BELOW EL. 980.7 WAS BETWEEN 2 AND 3 GPM.
4. ONE 3 IN. UNDISTURBED SAMPLE TAKEN BETWEEN EL. 992.7 AND 990.7 IN THE PILOT HOLE.
5. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

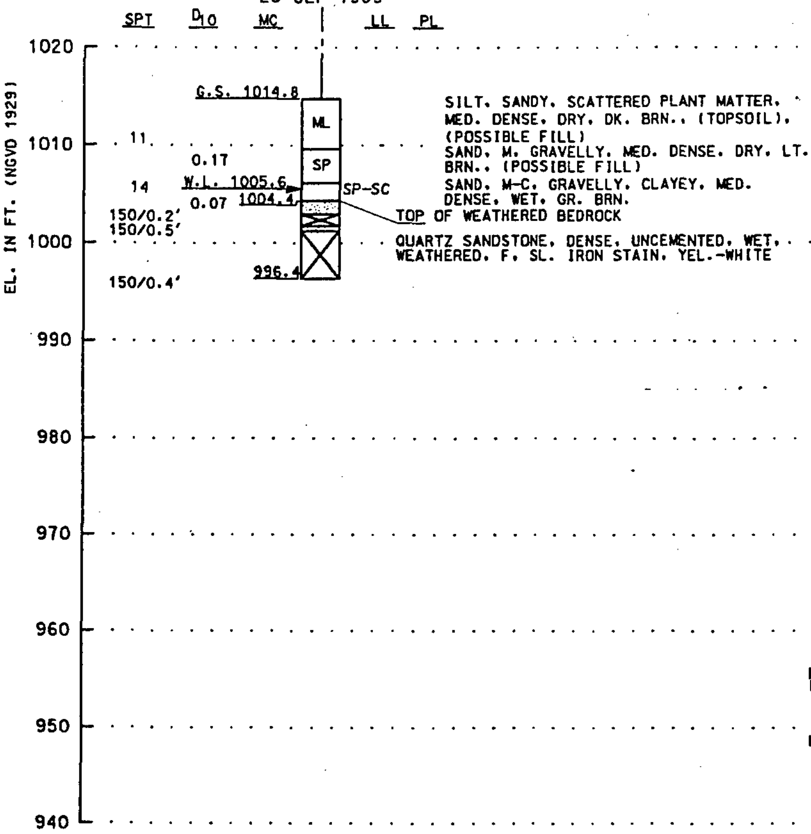
BORING LOGS
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
BORING LOGS 89-266M THRU 89-273M

ED-D DESIGNED: / CHECKED: / DRAWN:
ED-GH DESIGNED: LJL / CHECKED: DAC
DATE: 02-26-92

CAD FILE NAME: PLATE6.DGN
SPEC NO: DACW37-90-B-0000
DRAWING NUMBER: PLATE C-6
SHT 6 OF 7

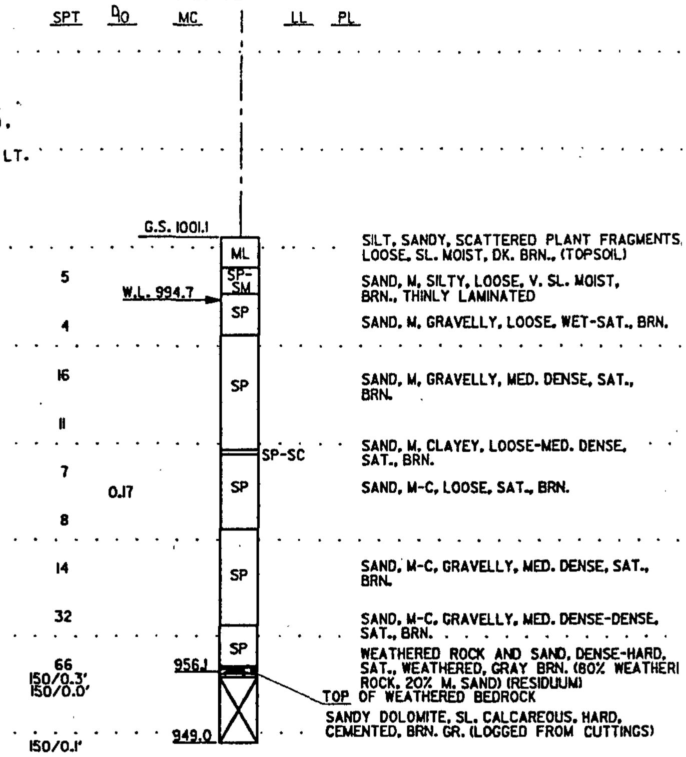
3

89-274M
28 SEP 1989



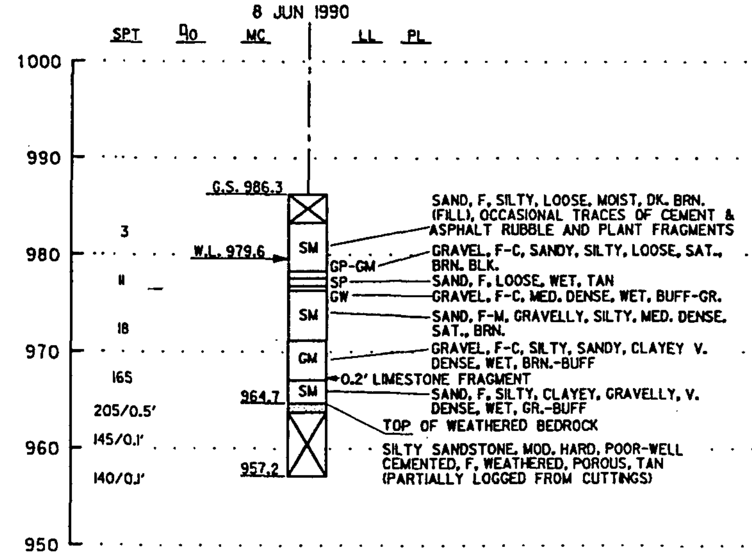
NOTES:
1. WATER LEVEL DETERMINED AFTER 15 MIN. WITH BOTTOM OF AUGER AT EL. 1004.8 AND SAMPLING TO EL. 1003.0. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 1005.2.
2. HOLLOW STEM AUGER SET TO EL. 1004.8. HOLE STABILIZED WITH DRILLING FLUID BELOW EL. 1004.8.
3. WATER LOSS BELOW EL. 1004.8 WAS BETWEEN 2 AND 3 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

89-275M
28-29 SEP 1989



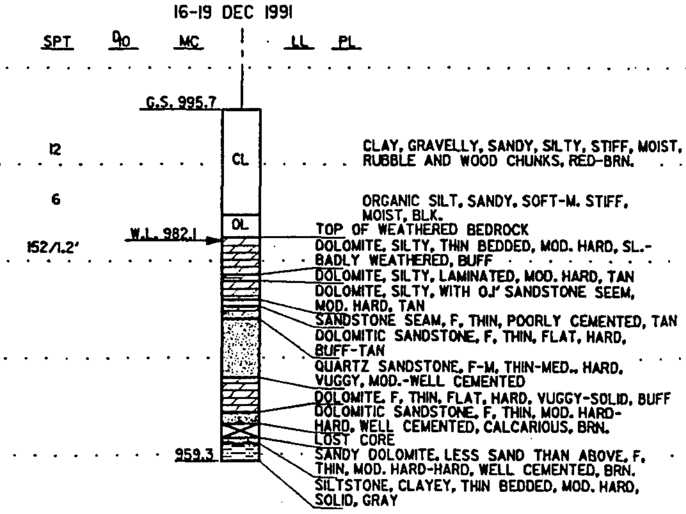
NOTES:
1. WATER LEVEL DETERMINED AFTER 45 MIN. WITH BOTTOM OF AUGER AND SAMPLING TO EL. 988.1. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 989.5. ADJACENT CREEK EL. 994.3.
2. HOLLOW STEM AUGER SET TO EL. 986.1. HOLE STABILIZED WITH DRILLING MUD BELOW 986.1.
3. WATER LOSS 2-5 GPM BETWEEN EL. 971.1 TO EL. 955.1.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

90-282M
8 JUN 1990



NOTES:
1. WATER LEVEL DETERMINED AFTER 90 MIN. WITH BOTTOM OF AUGER AT EL. 981.3 AND SAMPLING TO EL. 976.3. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 978.5.
2. HOLLOW STEM AUGER ADVANCED TO 976.3 AND SET TO EL. 972.3. DRILLING MUD USED TO STABILIZE HOLE BELOW EL. 972.3.
3. WATER LOSS BETWEEN EL. 971.3 AND 966.3 WAS 20 GPM. WATER LOSS BELOW EL. 966.3 WAS BETWEEN 0 AND 2 GPM. WATER LOSS ABOVE EL. 971.3 WAS BETWEEN 0 AND 2 GPM.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

91-295M
16-19 DEC 1991



NOTES:
1. WATER LEVEL DETERMINED AFTER 15 HRS. WITH:
BOTTOM OF HSA AT EL. 981.7
BOTTOM OF HOLE AT EL. 981.9
AFTER SAMPLING TO EL. 981.5.
2. REMOVED HSA AND INSTALLED 6' CASING TO EL. 981.7.
3. 4' CORE BARREL USED BELOW EL. 981.5.
4. WATER LOSS OF 4 GPM BETWEEN EL. 979.7 AND 975.3. NO WATER RETURN BETWEEN EL. 967.9 AND EL. 959.3.
5. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

M
89
LL PL

SILT, SANDY, SCATTERED PLANT FRAGMENTS, LOOSE, SL. MOIST, DK. BRN., (TOPSOIL)
SAND, M, SILTY, LOOSE, V. SL. MOIST, BRN., THINLY LAMINATED
SAND, M, GRAVELLY, LOOSE, WET-SAT., BRN.
SAND, M, GRAVELLY, MED. DENSE, SAT., BRN.
SC
SAND, M, CLAYEY, LOOSE-MED. DENSE, SAT., BRN.
SAND, M-C, LOOSE, SAT., BRN.
SAND, M-C, GRAVELLY, MED. DENSE, SAT., BRN.
SAND, M-C, GRAVELLY, MED. DENSE-DENSE, SAT., BRN.
WEATHERED ROCK AND SAND, DENSE-HARD, SAT., WEATHERED, GRAY BRN. (80% WEATHERED ROCK, 20% M. SAND) (RESIDUUM)
TOP OF WEATHERED BEDROCK
SANDY DOLOMITE, SL. CALCAREOUS, HARD, CEMENTED, BRN. GR. (LOGGED FROM CUTTINGS)

AFTER 45 MIN. WITH BOTTOM OF
EL. 988.1. CAVE-IN LEVEL &/OR
989.5. ADJACENT CREEK EL. 994.3.
TO EL. 986.1. HOLE STABILIZED WITH
.1.
TWEEN EL. 971.1 TO EL. 955.1.
EMIED CEMENT-BENTONITE GROUT.

89-276M
29 SEP 1989

SPT | q_o | MC | LL | PL

G.S. 1002.5
W.L. 994.4

SPT	q_o		Description
		SM	SAND, M, SILTY, LOOSE, DRY, DK. BRN.
4		SP	SAND, M, LOOSE, DRY, BRN.
2		SP	SAND, M, GRAVELLY, LOOSE, WET, BRN-GR.
		GP-GC	GRAVEL, F-M, SANDY, CLAYEY, MED. DENSE, SAT., BRN.
17		SP	SAND, M, GRAVELLY, MED. DENSE, SAT., BRN.
	0.07	SP-SC	SAND, M, CLAYEY, MED. DENSE, SAT., BRN.
15	0.09	SP	SAND, M, MED. DENSE, SAT., BRN.
17		SP	SAND, M, MED. DENSE, SAT., BRN.
16			
32		SP	SAND, M-C, GRAVELLY, MED. DENSE, SAT., BRN.
30	0.12		962.5

NOTES:
1. WATER LEVEL DETERMINED AFTER 20 MINUTES WITH BOTTOM OF AUGER AT EL. 992.5 AND SAMPLING TO EL. 987.5. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 993.3. ADJACENT CREEK EL. 994.3.
2. HOLLOW STEM AUGER SET TO EL. 987.5. HOLE STABILIZED WITH DRILLING MUD BELOW 987.5.
3. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

90-281M
7 JUN 1990

SPT | q_o | MC | LL | PL

G.S. 994.3
W.L. 981.3

SPT		Description
	SM	SAND, F, BRN., (FI
11	SM	SAND, F, MED. DEN
28	SM	SAND, V, & BRICK
	ML	SILT, SAN DK. BRN.
18	SP-SM	SAND, F-I MOIST-SA
40	GP-GM	GRAVEL, SAT., BUF
104/0.1'	973.4	TOP OF WEATHE
150/0.1'		SANDSTONE, MA: HARD, POORLY (TEXTURE, WEATH OCC. IRON STAIN (GRADES INTO L SILTY LIMESTON CALCAREOUS, SIL DENSE, FLAT BE NON SWELLING, I CUTTINGS)
183/0.1'	965.2	

NOTES:
1. WATER LEVEL DETERMINED AFTER 40 MIN. WI AUGER AT EL. 979.3 AND SAMPLING TO EL. LEVEL &/OR HEAVE MEASURED AT EL. 978.7
2. HOLLOW STEM AUGER SET TO EL. 975.3. HOL WITH DRILLING MUD BELOW EL. 975.3.
3. 100% WATER LOSS BELOW EL. 975.3.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BEN

PL

CLAY, GRAVELLY, SANDY, SILTY, STIFF, MOIST, RUBBLE AND WOOD CHUNKS, RED-BRN.
ORGANIC SILT, SANDY, SOFT-M. STIFF, MOIST, BLK.
TOP OF WEATHERED BEDROCK
DOLOMITE, SILTY, THIN BEDDED, MOD. HARD, SL.-BADLY WEATHERED, BUFF
DOLOMITE, SILTY, LAMINATED, MOD. HARD, TAN
DOLOMITE, SILTY, WITH 0.1' SANDSTONE SEEM, MOD. HARD, TAN
SANDSTONE SEAM, F, THIN, POORLY CEMENTED, TAN
DOLOMITIC SANDSTONE, F, THIN, FLAT, HARD, BUFF-TAN
QUARTZ SANDSTONE, F-M, THIN-MED., HARD, VUGGY, MOD.-WELL CEMENTED
DOLOMITE, F, THIN, FLAT, HARD, VUGGY-SOLID, BUFF
DOLOMITIC SANDSTONE, F, THIN, MOD. HARD-HARD, WELL CEMENTED, CALCARIOUS, BRN.
LOST CORE
SANDY DOLOMITE, LESS SAND THAN ABOVE, F, THIN, MOD. HARD-HARD, WELL CEMENTED, BRN.
SILTSTONE, CLAYEY, THIN BEDDED, MOD. HARD, SOLID, GRAY

TER 15 HRS. WITH:
1.7
1.9
.5.
6' CASING TO EL. 981.7.
EL. 981.5.
EEN EL. 979.7 AND 975.3. NO
967.9 AND EL. 959.3.
D CEMENT-BENTONITE GROUT.

92-296M
8-9 JAN 1992

SPT | q_o | MC | LL | PL

G.S. 991.5
W.L. 980.8
958.9

SPT		Description
	CH	CLAY, SANDY, SILTY, GRAVELLY, SOFT, MOIST-, WET, SOME RUBBLE, BRN. (FILL)
	SM	SAND, SILTY, LOOSE, MOIST, BRN.
2	GC	CLAY, GRAVELLY, SILTY, SANDY, LOOSE, MOIST, RUBBLE, BRN. (FILL)
4		TOP OF WEATHERED BEDROCK

SANDY DOLOMITE, F, THIN, FLAT, SOFT, BADLY WEATHERED, POROUS, TAN
DOLOMITE, SILTY, F, THIN, FLAT, MOD. HARD, SHALE LAYER 980.3-980.1, BUFF
DOLOMITIC SHALE, F, V. THIN, FLAT, SOFT-HARD, GRAY-TAN
DOLOMITE, SILTY, F, THIN, FLAT, HARD-V. HARD, SOLID, TAN
DOLOMITE SANDSTONE, F, THIN, FLAT, HARD, SOLID, LT. TAN
DOLOMITE, SILTY, SANDY, F, THIN, FLAT, V. HARD, VUGGY, BUFF
LOST CORE
DOLOMITIC SANDSTONE, F-M, HARD, SOLID, WELL CEMENTED, TAN
SANDSTONE, F, V.THIN-THIN, FLAT, HARD-FRIABLE, TAN
DOLOMITE, SILTY, SANDY, THIN, FLAT, V. HARD, VUGGY, TAN
DOLOMITE, SILTY, THIN, FLAT, V. HARD, BUFF
LOST CORE
DOLOMITIC SANDSTONE, F, V. THIN-THIN, HARD-V. HARD, WELL CEMENTED, LT. TAN
DOLOMITE, SILTY, CONGLOMERATE, THIN, V. HARD, VUGGY, TAN
SILTSTONE, F, THIN, FLAT, HARD-V. HARD, SOLID, LT. BUFF

1000
990
980
970
960
950

NOTES:
1. WATER LEVEL NOT DETERMINED. BEAR CREEK WATER EL. 980.0, ADJACENT TO HOLE.
2. HSA SET TO EL. 981.5. HSA REMOVED AND 8" CASING INSTALLED TO EL. 981.3.
3. 4" CORE BARREL USED BELOW EL. 981.0.
4. NO WATER RETURN BETWEEN EL. 978.3 AND EL. 958.9
5. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

2

SYMBOL	DESCRIP
AE APPROVING OFFICIAL:	FLOOD CON
ED-D DESIGNED:	
ED-D CHECKED:	ST
ED-D DRAWN:	BORING LOGS
ED-GH DESIGNED: LJL	90-
ED-GH CHECKED: DAC	CAD FILE NAME: PLATI
DATE: 02-26-92	SPEC NO: DACW37-90-B-

E F

90-281M
7 JUN 1990

LL PL SPT D_0 MC LL PL

1020
1010
1000
990
980
970
960
950
940

SAND, M, SILTY, LOOSE, DRY, DK. BRN.
SAND, M, LOOSE, DRY, BRN.
SAND, M, GRAVELLY, LOOSE, WET, BRN-GR.
GC GRAVEL, F-M, SANDY, CLAYEY, MED. DENSE, SAT., BRN.
SAND, M, GRAVELLY, MED. DENSE, SAT., BRN.
SC SAND, M, CLAYEY, MED. DENSE, SAT., BRN.
SAND, M, MED. DENSE, SAT., BRN.
SAND, M, MED. DENSE, SAT., BRN.
SAND, M-C, GRAVELLY, MED. DENSE, SAT., BRN.

SPT: 11, 28, 18, 40, 104/0.J', 150/0.J', 183/0.F'

G.S. 994.3
W.L. 981.3
973.4
965.2

SM, SM, SM, ML, SP-SM, GP-GM

SAND, F, SILTY, GRAVELLY, LOOSE, MOIST, BRN., (FILL)
SAND, F, SILTY, GRAVELLY, CONCRETE RUBBLE, MED. DENSE, DRY-MOIST, LT. BRN.-BUFF GR.
SAND, V. F, SILTY, GRAVELLY, CONCRETE AND & BRICK RUBBLE, DENSE, DRY, GR.-RED, (FILL)
SILT, SANDY, CLAYEY, MED. DENSE, MOIST, DK. BRN.
SAND, F-M, GRAVELLY, SILTY, MED. DENSE, MOIST-SAT., BRN.
GRAVEL, F, SANDY, SILTY, CLAYEY, DENSE, SAT., BUFF-BRN.
TOP OF WEATHERED BEDROCK
SANDSTONE, MASSIVE, SL. CALCAREOUS, MOD. HARD, POORLY CEMENTED, FRIABLE, MED. TEXTURE, WEATHERED, POROUS, SLAKES SLOWLY, OCC. IRON STAIN, OCC. CONCRETIONS, TAN, (GRADES INTO LIMESTONE AT APPROX. EL. 970.3)
SILTY LIMESTONE, THINLY BEDDED, PLATY, CALCAREOUS, SILTY, HARD, WELL CEMENTED, DENSE, FLAT BEDDED, SL. WEATHERED, SOLID, NON SWELLING, NON SLAKING, BUFF (LOGGED FROM CUTTINGS)

ED AFTER 20 MINUTES WITH BOTTOM OF
D SAMPLING TO EL. 987.5. CAVE-IN
ASURED AT EL. 993.3. ADJACENT CREEK

SET TO EL. 987.5. HOLE STABILIZED WITH
87.5.
TREMIED CEMENT-BENTONITE GROUT.

NOTES:

1. WATER LEVEL DETERMINED AFTER 40 MIN. WITH BOTTOM OF AUGER AT EL. 979.3 AND SAMPLING TO EL. 974.3. CAVE-IN LEVEL &/OR HEAVE MEASURED AT EL. 978.7.
2. HOLLOW STEM AUGER SET TO EL. 975.3. HOLE STABILIZED WITH DRILLING MUD BELOW EL. 975.3.
3. 100% WATER LOSS BELOW EL. 975.3.
4. HOLE BACKFILLED WITH TREMIED CEMENT-BENTONITE GROUT.

L PL

1000
990
980
970
960
950

CLAY, SANDY, SILTY, GRAVELLY, SOFT, MOIST-, WET, SOME RUBBLE, BRN. (FILL)
SAND, SILTY, LOOSE, MOIST, BRN.
CLAY, GRAVELLY, SILTY, SANDY, LOOSE, MOIST, RUBBLE, BRN. (FILL)
TOP OF WEATHERED BEDROCK
SANDY DOLOMITE, F, THIN, FLAT, SOFT, BADLY WEATHERED, POROUS, TAN
DOLOMITE, SILTY, F, THIN, FLAT, MOD. HARD, SHALE LAYER 980.3-980.1, BUFF
DOLOMITIC SHALE, F, V. THIN, FLAT, SOFT-HARD, GRAY-TAN
DOLOMITE, SILTY, F, THIN, FLAT, HARD-V. HARD, SOLID, TAN
DOLOMITE SANDSTONE, F, THIN, FLAT, HARD, SOLID, LT. TAN
DOLOMITE, SILTY, SANDY, F, THIN, FLAT, V. HARD, VUGGY, BUFF
LOST CORE
DOLOMITIC SANDSTONE, F-M, HARD, SOLID, WELL CEMENTED, TAN
SANDSTONE, F, V.THIN-THIN, FLAT, HARD-FRIABLE, TAN
DOLOMITE, SILTY, SANDY, THIN, FLAT, V. HARD, VUGGY, TAN
DOLOMITE, SILTY, THIN, FLAT, V. HARD, BUFF
LOST CORE
DOLOMITIC SANDSTONE, F, V. THIN-THIN, HARD-V. HARD, WELL CEMENTED, LT. TAN
DOLOMITE, SILTY, CONGLOMERATE, THIN, V. HARD, VUGGY, TAN
SILTSTONE, F, THIN, FLAT, HARD-V. HARD, SOLID, LT. BUFF

RMINED.
980.0, ADJACENT TO HOLE.

SING INSTALLED TO EL. 981.3.
ELOW EL. 981.0.
EEN EL. 978.3 AND EL. 958.9
REMIED CEMENT-BENTONITE GROUT.

3

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

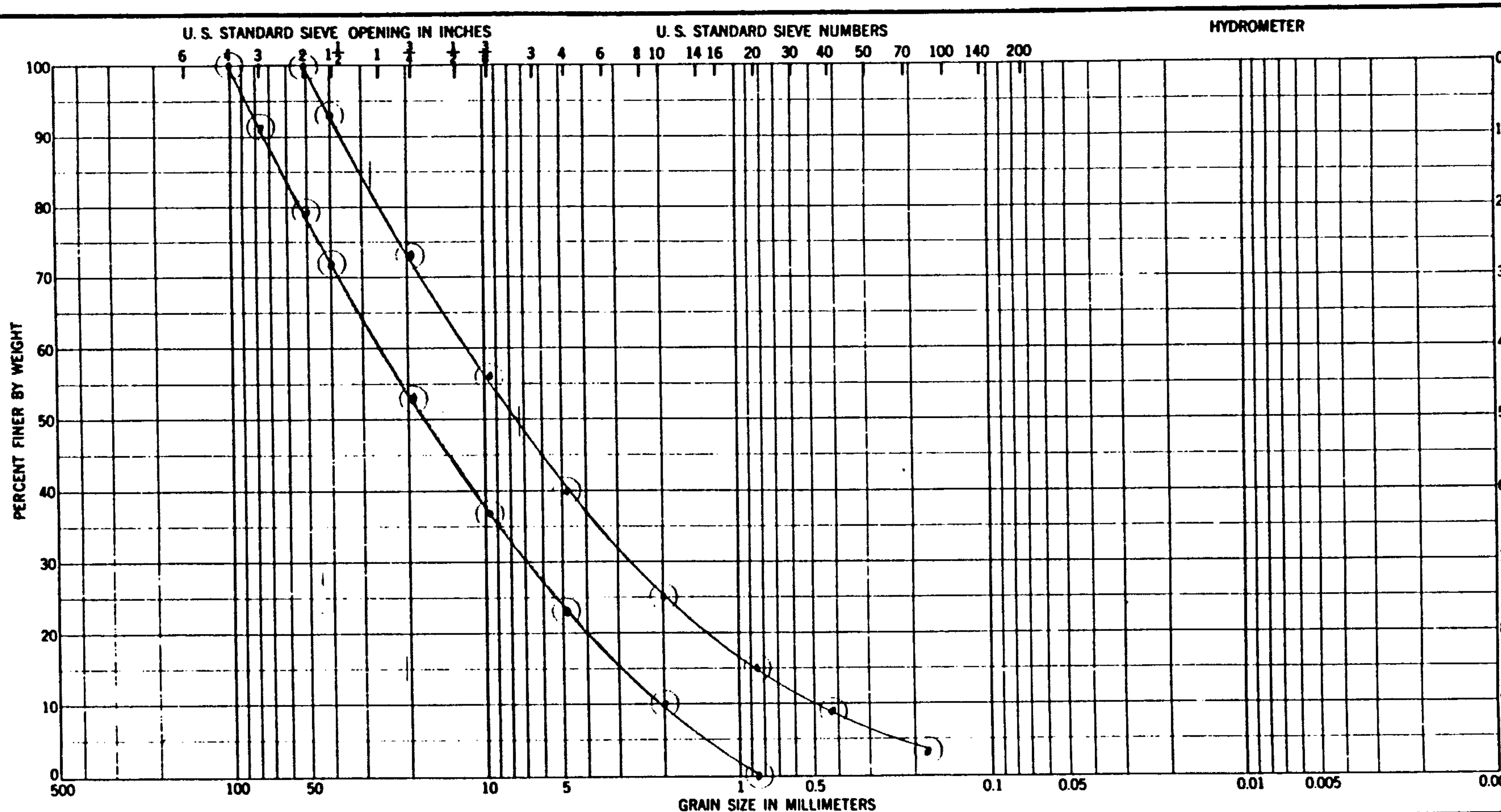
BORING LOGS
FLOOD CONTROL - SOUTH FORK ZUMBRO RIVER
ROCHESTER, MINNESOTA
STAGE 4 - BEAR CREEK
BORING LOGS 89-274M THRU 89-276M, 90-281M, 90-282M, 91-295M, 92-296M

ED-D: DESIGNED: / CHECKED: / DRAWN:
ED-GH: DESIGNED: LJL / CHECKED: DAC
DATE: 02-26-92
CAD FILE NAME: PLATE7.DGN
SPEC NO: DACW37-90-B-0000
DRAWING NUMBER: PLATE C-7
SHT 7 OF 7

APPENDIX C

GEOTECHNICAL DESIGN

RIPRAP AND BEDDING GRADATIONS



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project Rochester Flood Control
DM #6

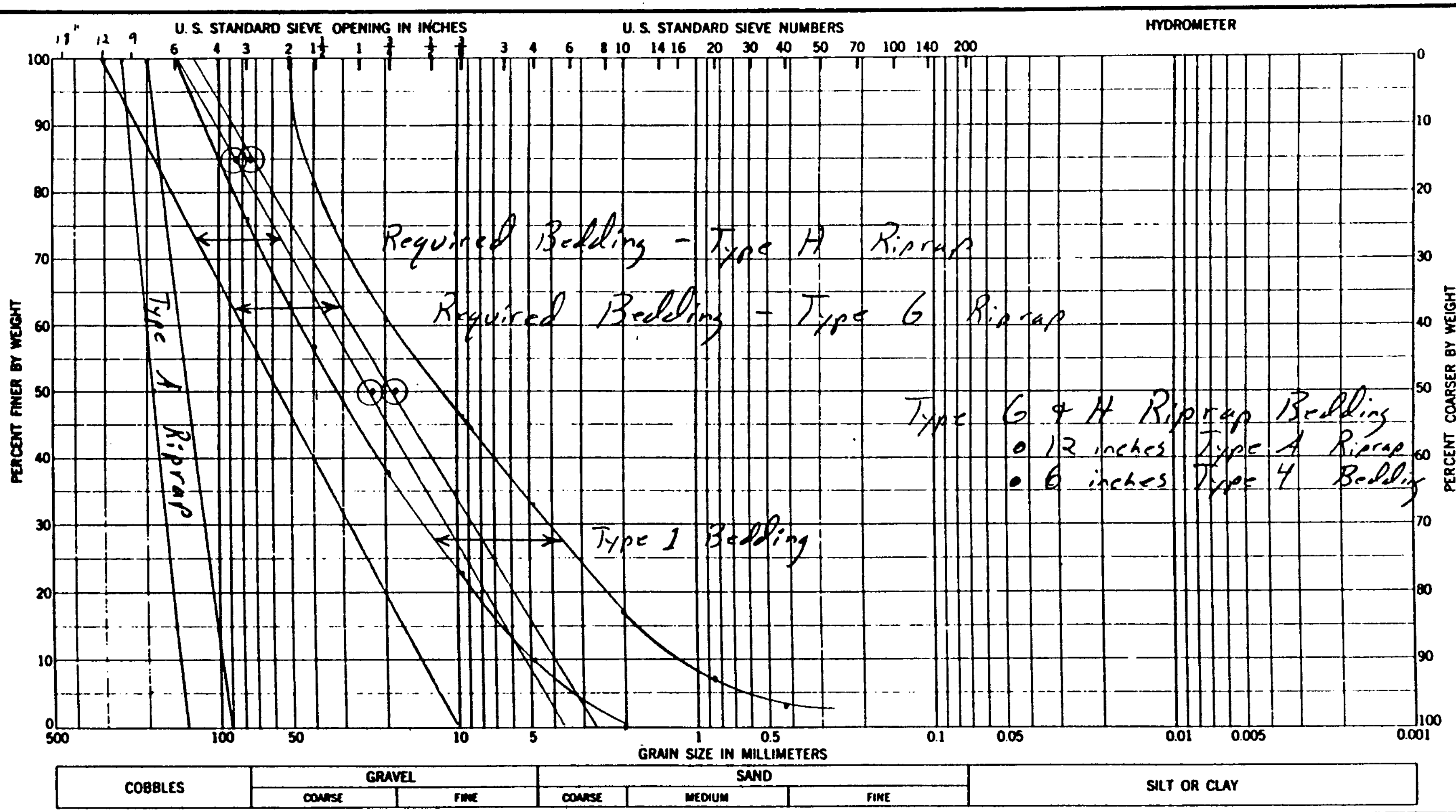
Area Stage 4

Boring No. Type 4 Bedding

Date Feb 1992

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project Rochester Stage IV
Bear Creek

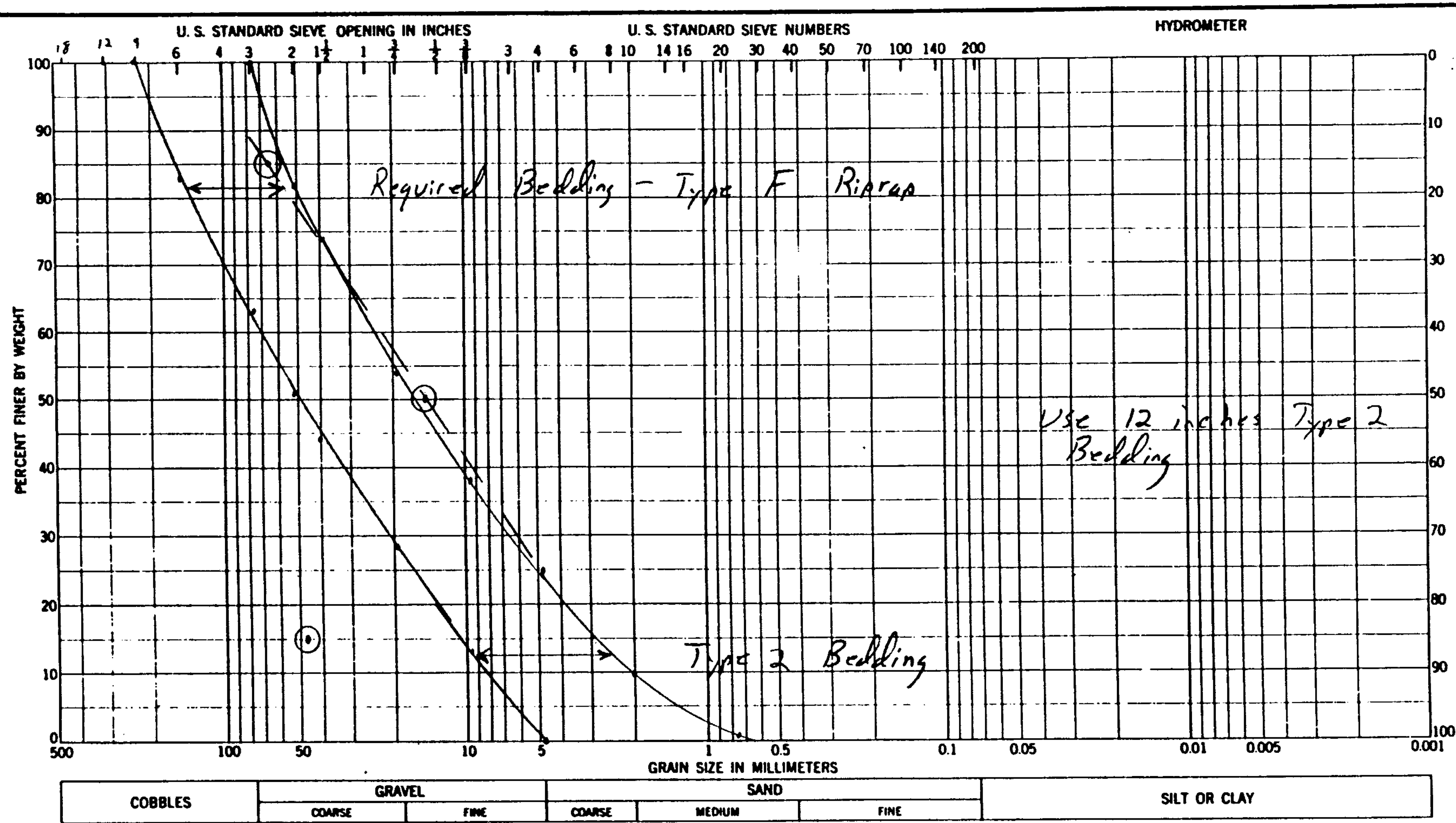
Area

Boring No. Type G + H Riprap Bedding

Date Nov. 4, 1991

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project Rochester Stage IV
Bear Creek

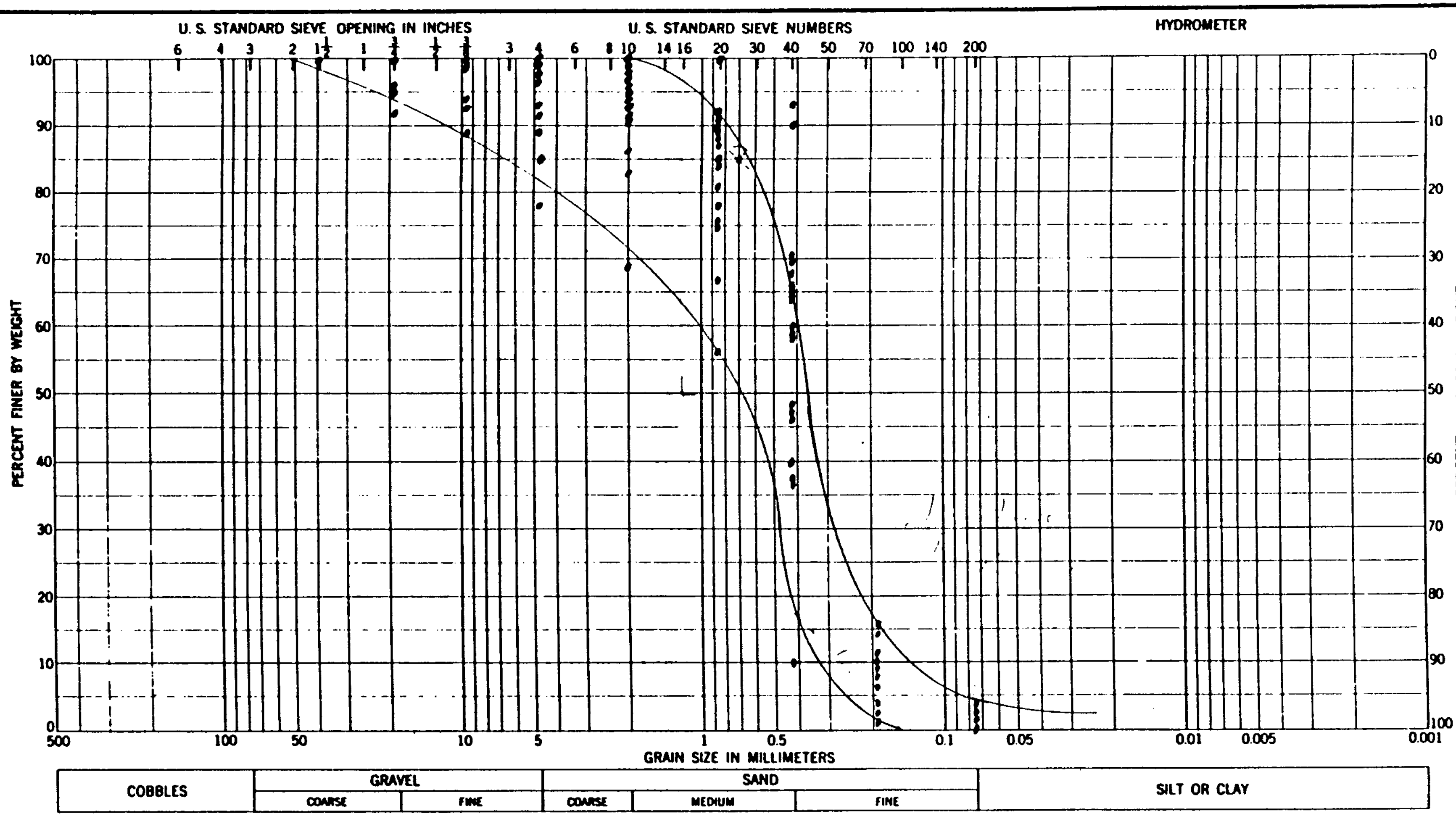
Area

Boring No. Type F Riprap Bedding

Date Nov. 4, 1991

GRADATION CURVES

ENG FORM 1 MAY 63 2087



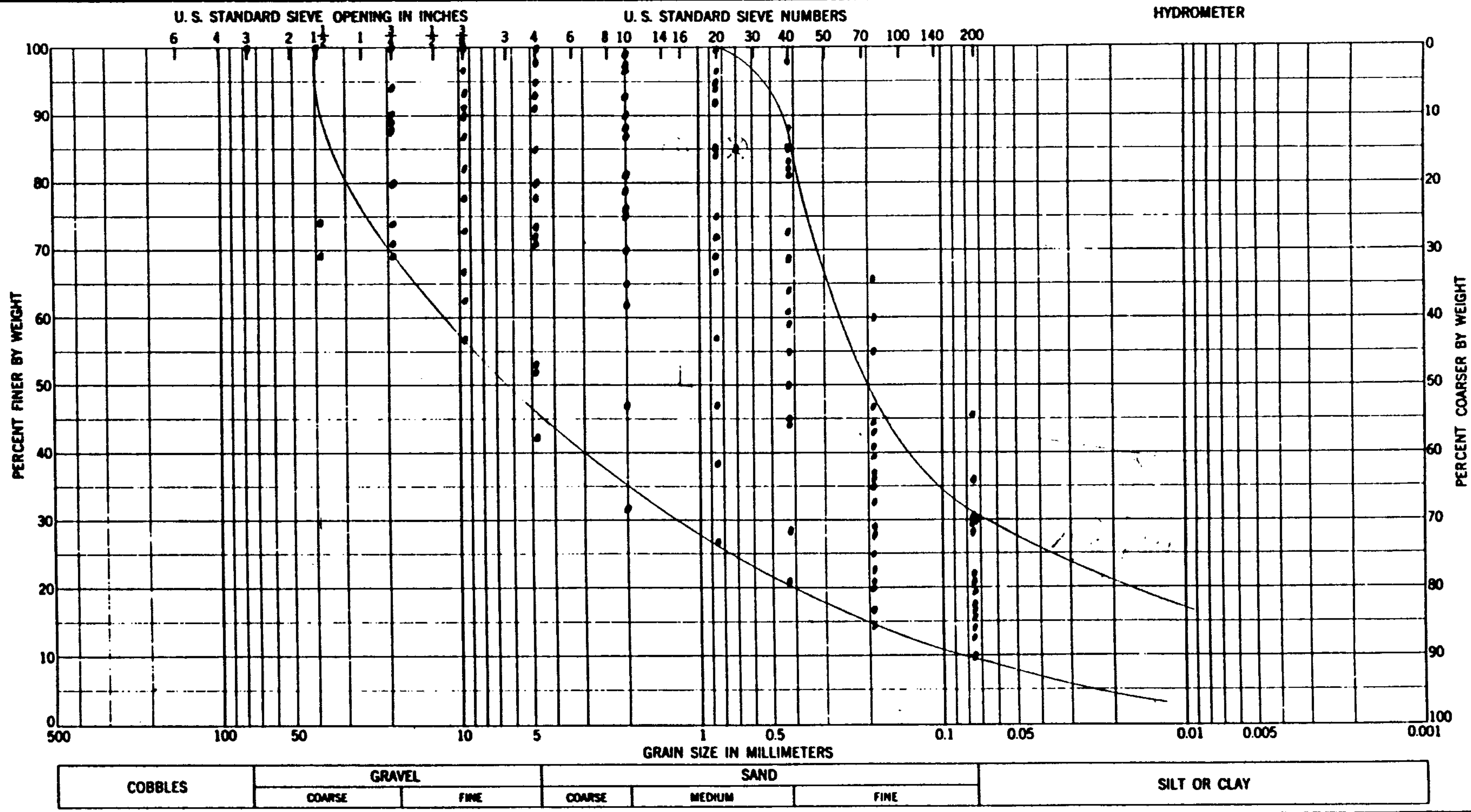
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
		(SP) Sands				

Project Bear Creek
Existing Subgrade
Area
Boring No.
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C - 11

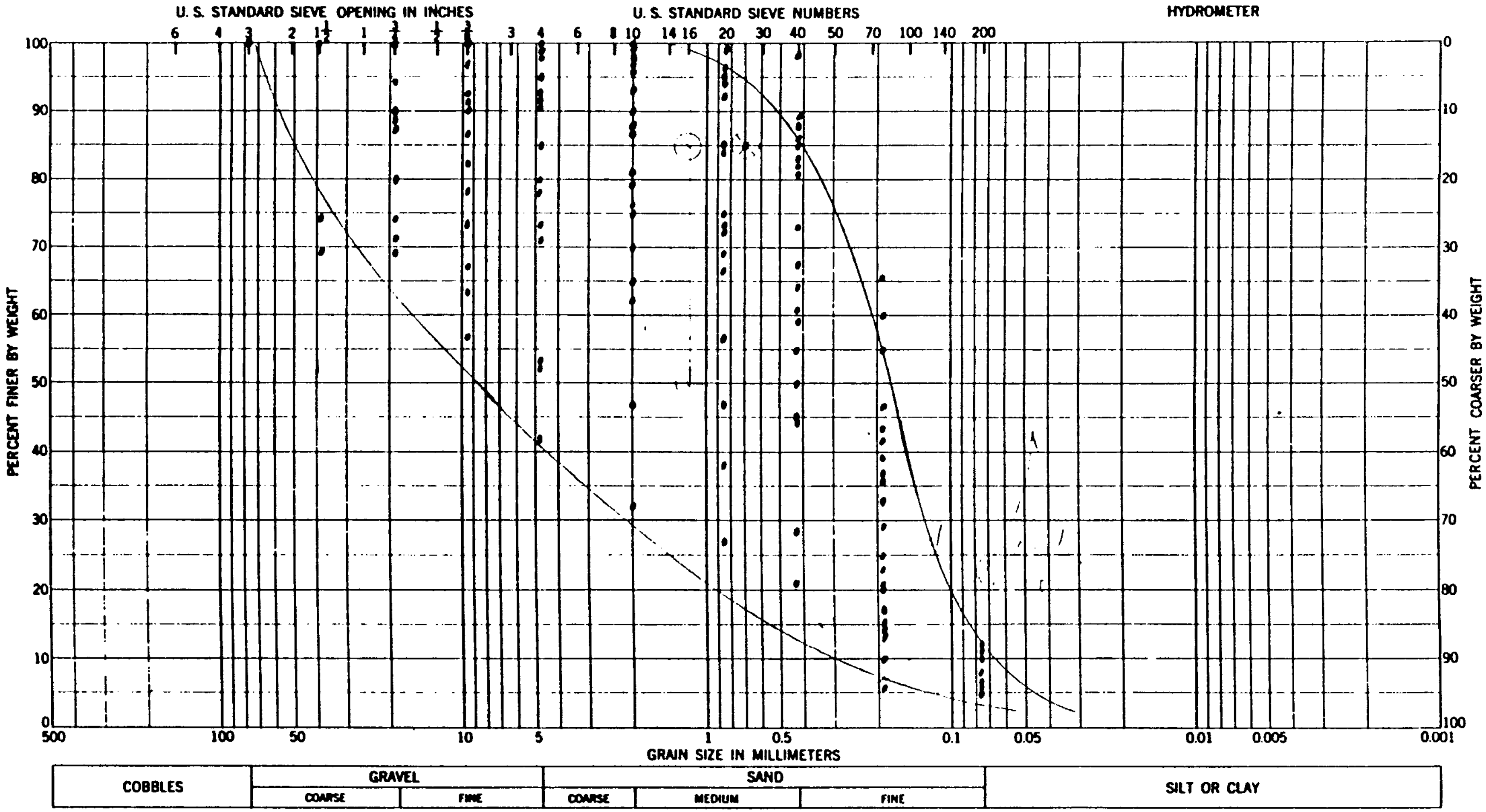


Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
		SM, SC & GM				

Project Bear Creek
Existing Subgrade
Area
Boring No.
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

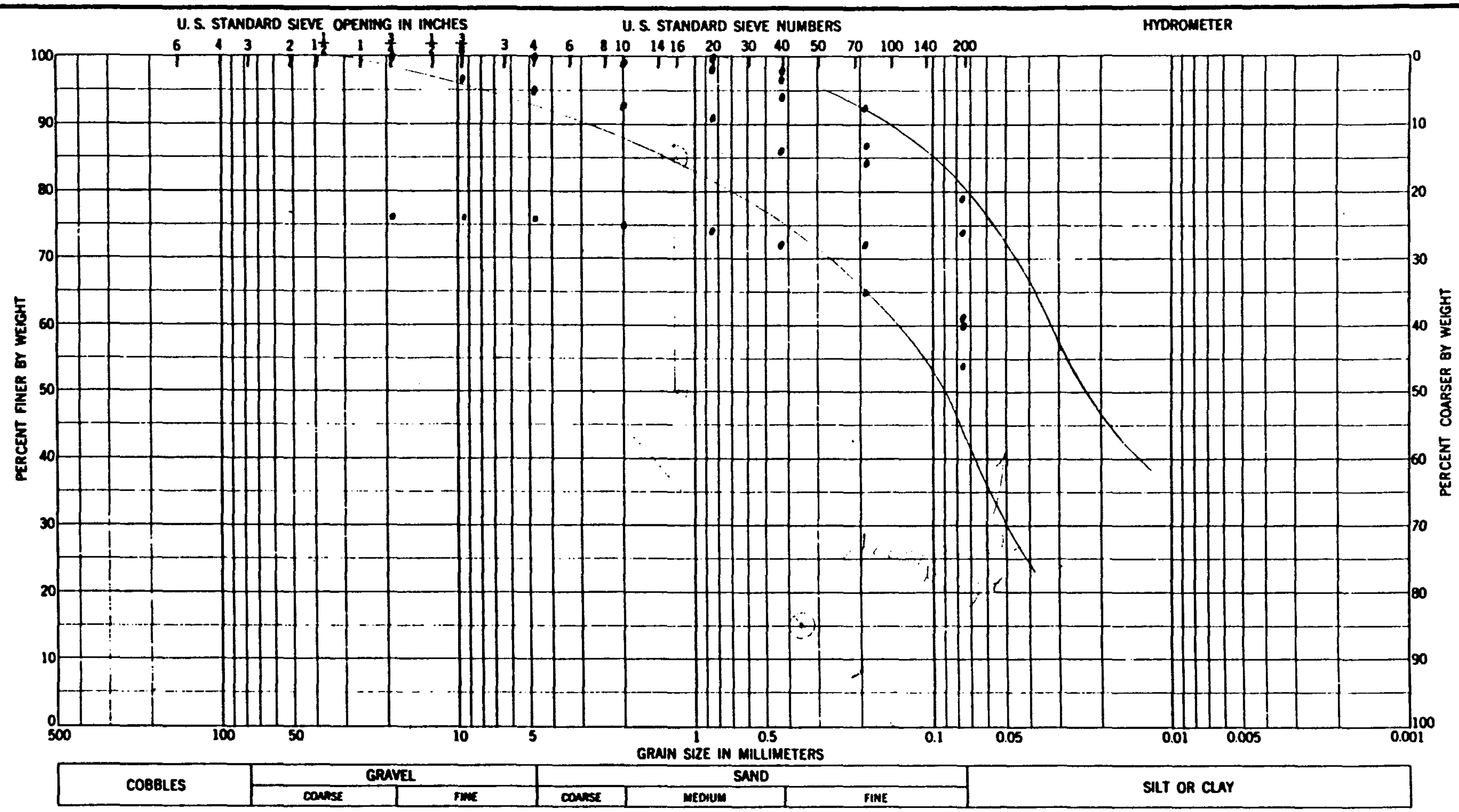


Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
		(SM-SP), (SM-SW)				
		(SM-GM), (GM-GP)				

Project Bear Creek
Existing Subgrade
Area
Boring No.
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
		(CL) 9 (ML)				

Project Bear Creek
Existing Subgrade
Area
Boring No.
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C – 14

APPENDIX C

GEOTECHNICAL DESIGN

CRITICAL FILTER CRITERIA CROSS SECTIONS

SUBJECT: Bedding Filter Criteria Cross Section @ 89-251 M	COMPUTED BY: Sta. 10+80	DATE: 11/4/91	FILE NO.
	CHECKED BY:	DATE:	SHEET NO.

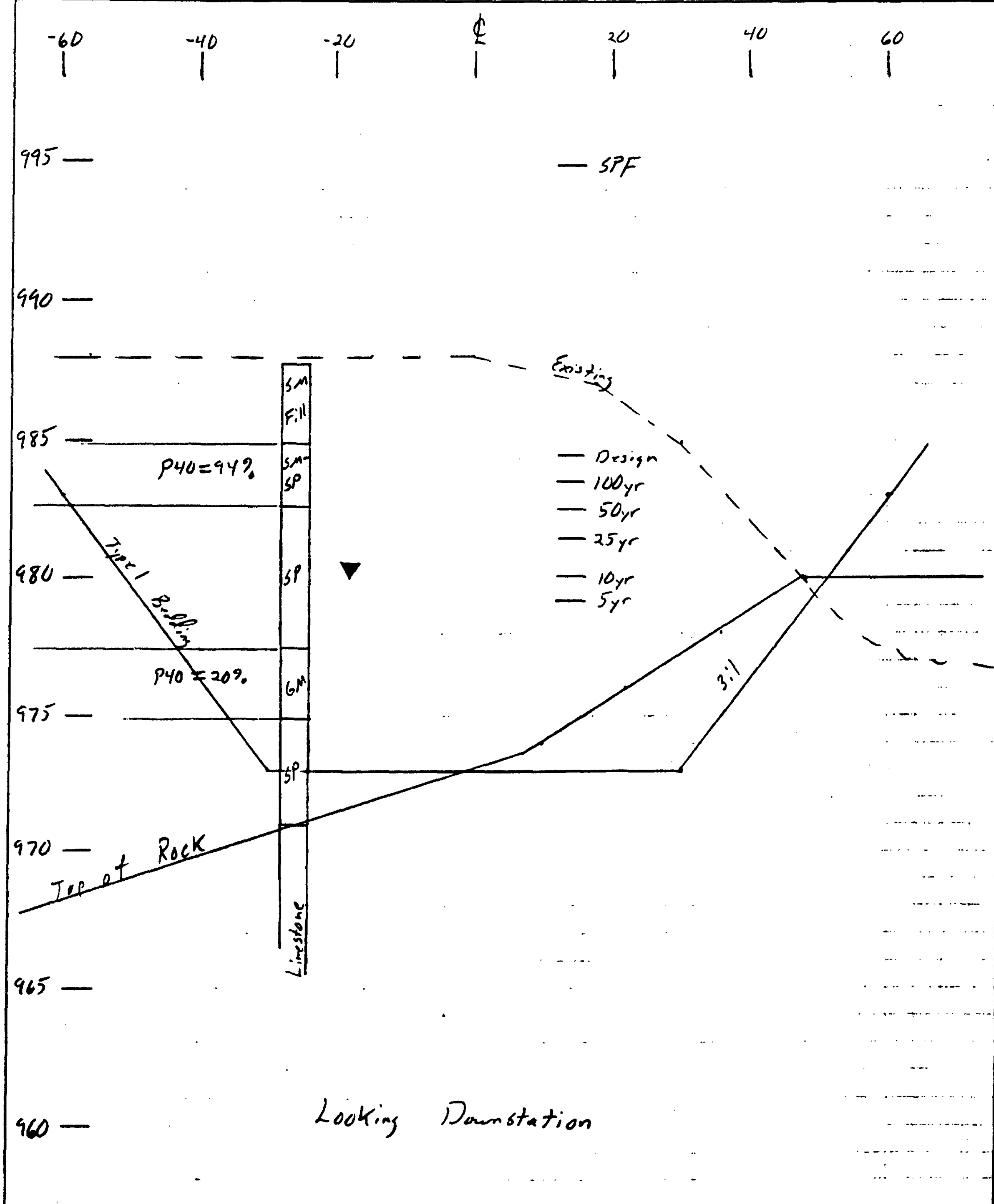


PLATE C – 15

WES FORM NO. 1253
REV OCT 1968

SUBJECT: 89-266 M Cross Section @ 89-267 M	COMPUTED BY: Sta. 24+00 – 24+80 CHECKED BY:	DATE: 11/4/91 DATE:	FILE NO. SHEET NO.

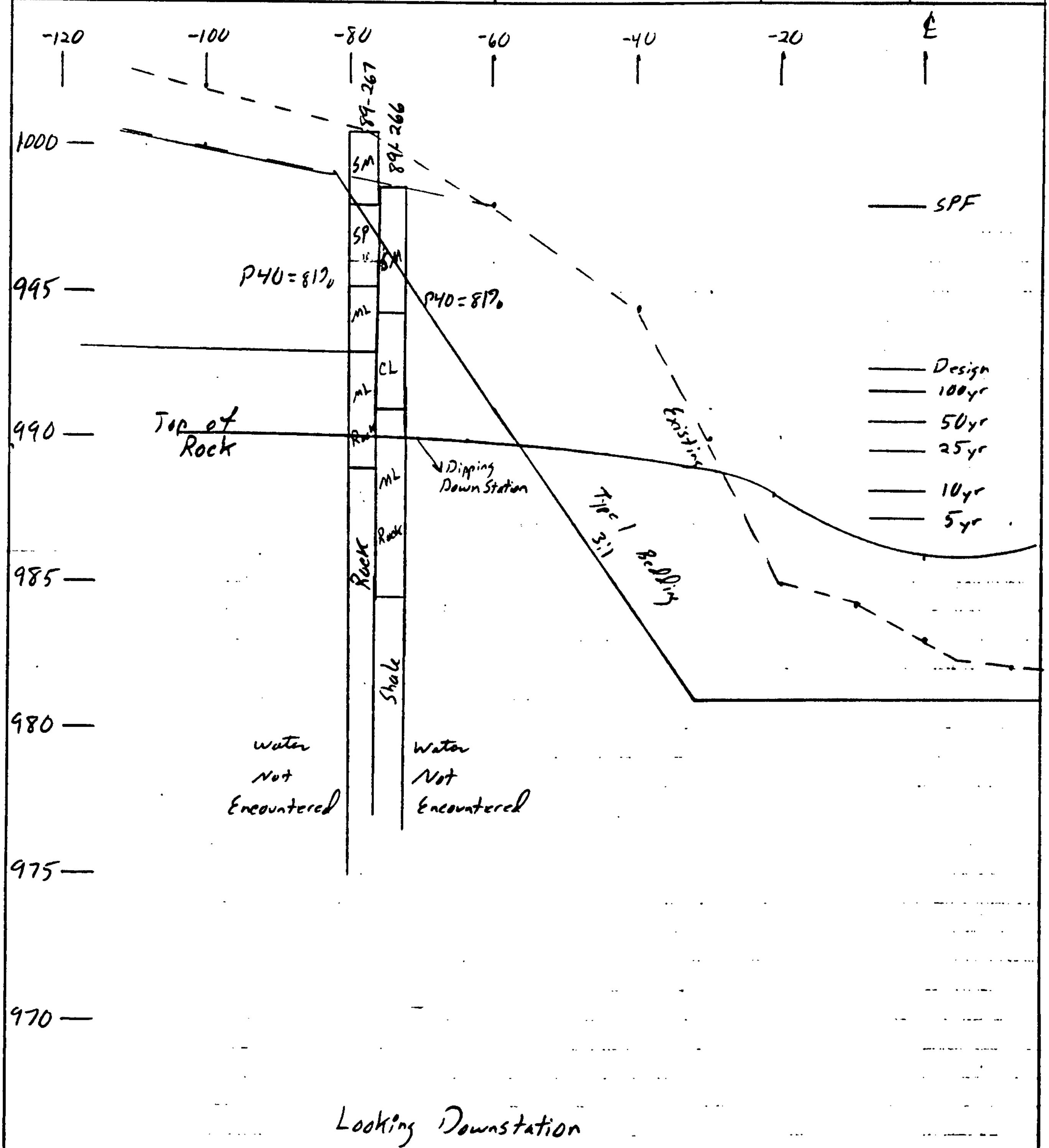


PLATE C – 16

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Bedding Filter Criteria Cross Section @ 89-245	COMPUTED BY: Sta. 18+00 CHECKED BY:	DATE: 11/4/91 DATE:	FILE NO. SHEET NO.

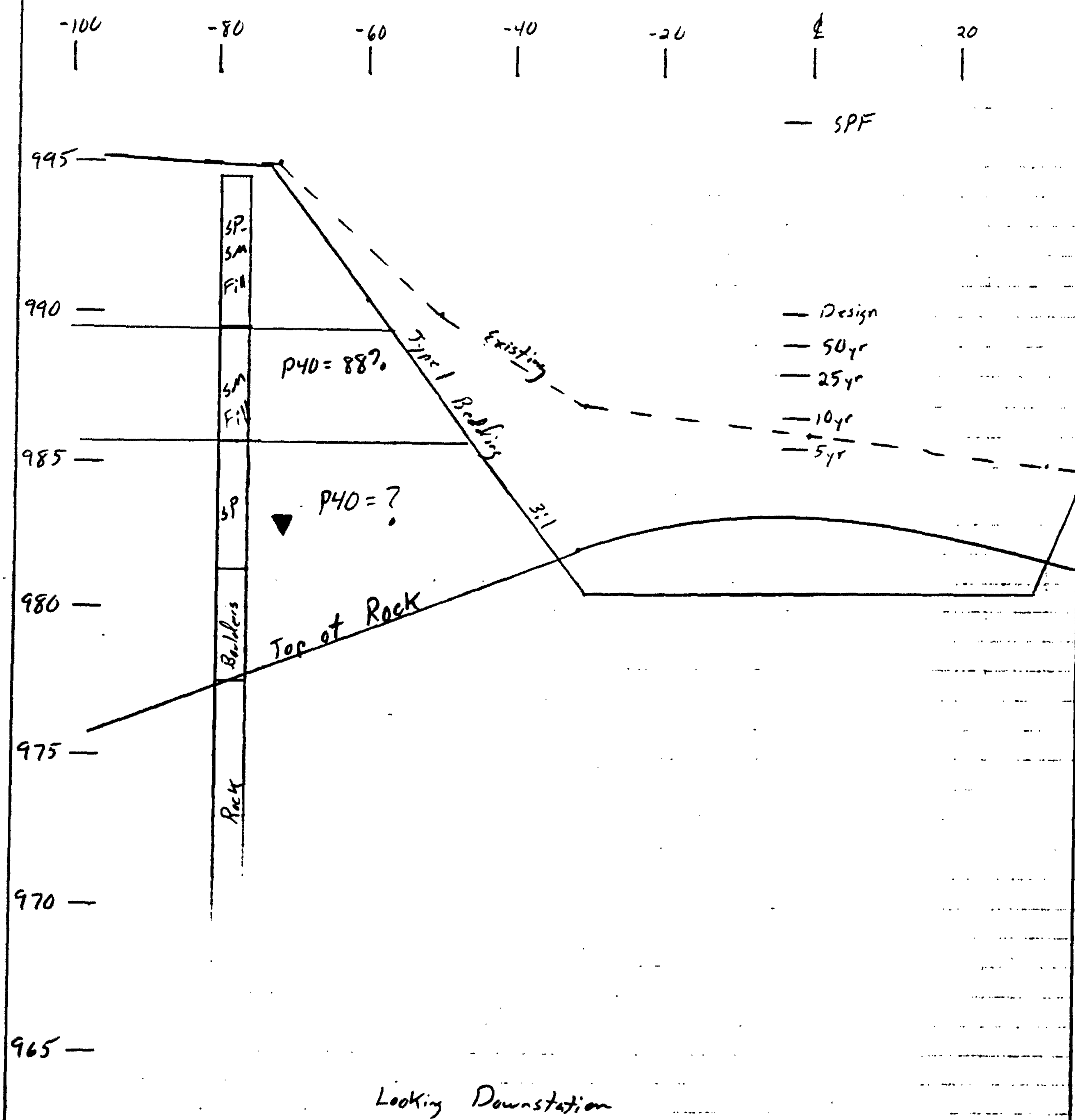


PLATE C – 17

SUBJECT: Bedding Filter Criteria Cross Section @ 81-33M	COMPUTED BY: Sta. 30+50	DATE: 11/4/91	FILE NO.
	CHECKED BY:	DATE:	SHEET NO.

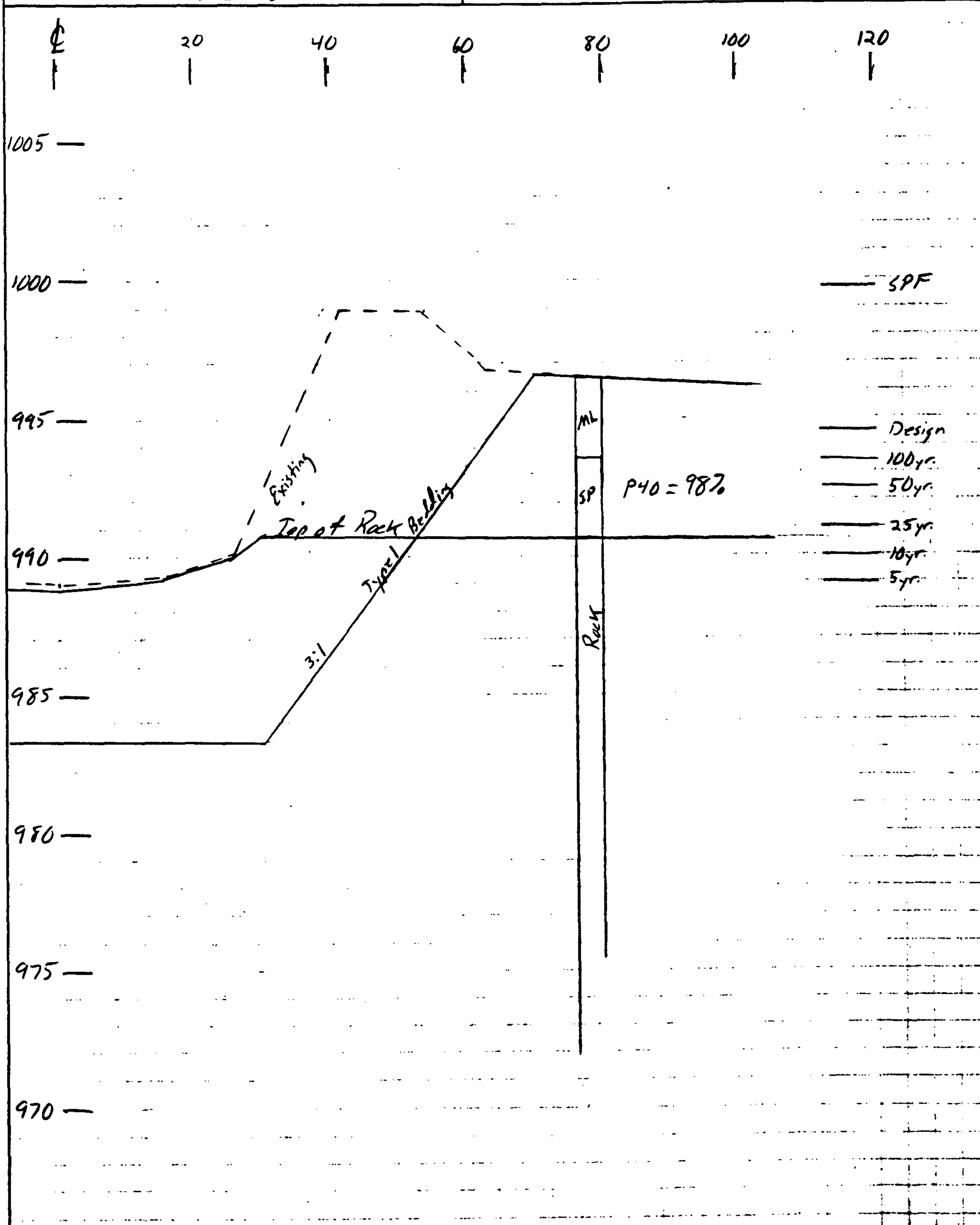


PLATE C – 18

WES FORM NO. 1253
REV OCT 1968

APPENDIX C

GEOTECHNICAL DESIGN

PLATES FOR TURF

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAL	DATE: 1/2/92	SHEET: Plate C-19
	SUBJECT TITLE: Erosion Control	CHECKED BY:	DATE:	CONTRACT NO.: ROCH 4 DM-6

Generalized Cost Estimate For Bear Creek

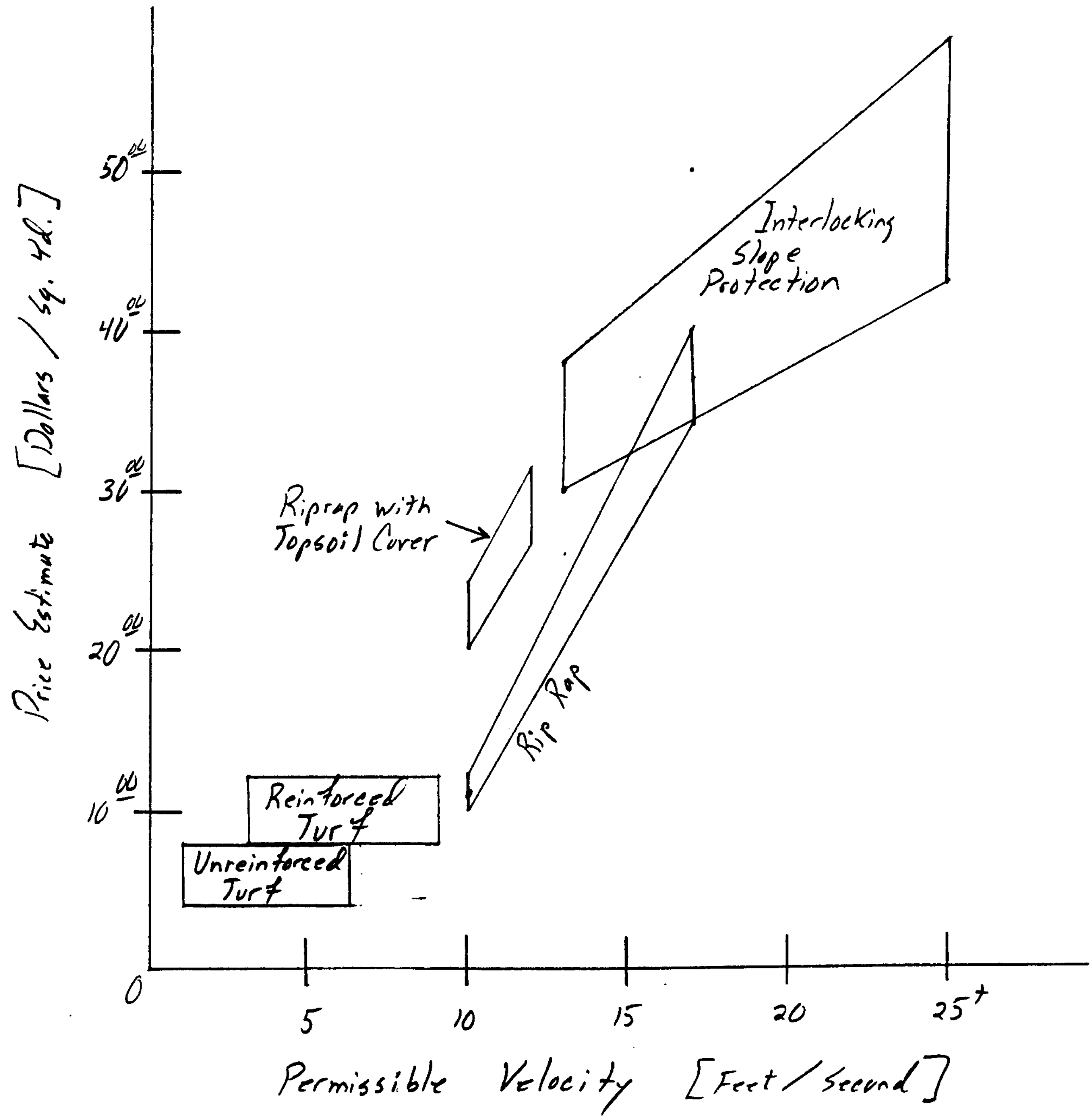


PLATE C-19

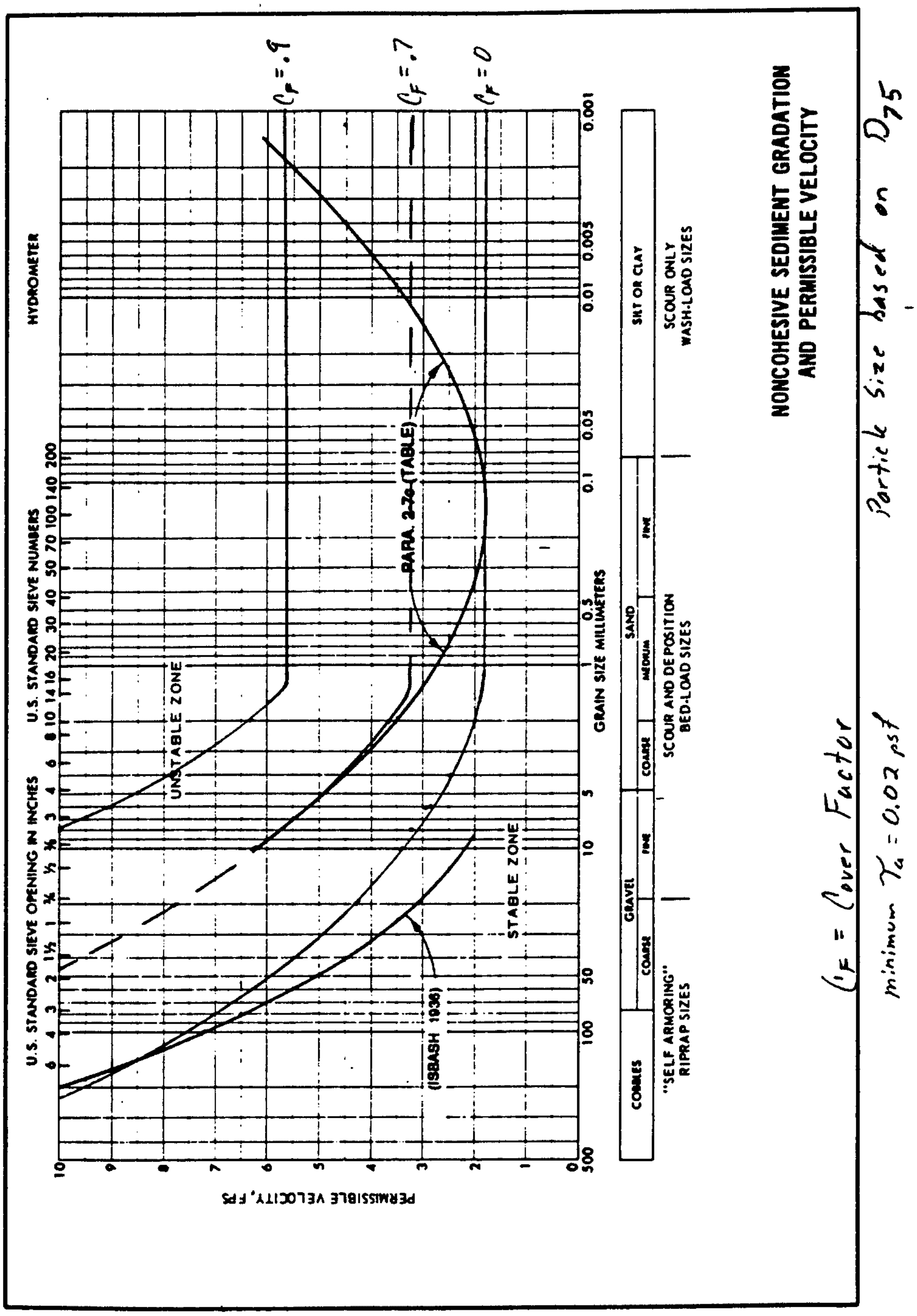
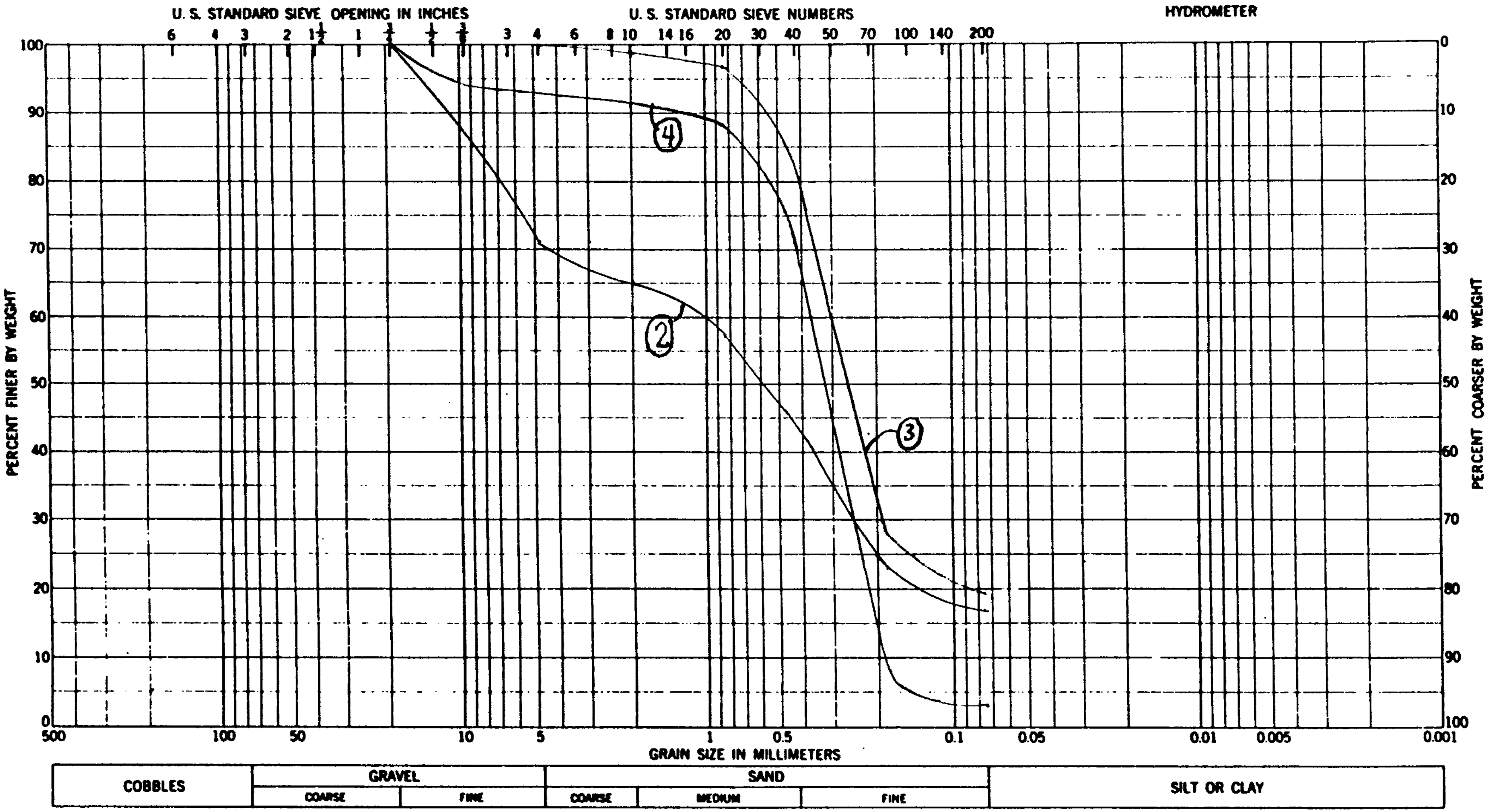

U.S. STANDARD SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
PERMISSIBLE VELOCITY, FPS
GRAIN SIZE MILLIMETERS
UNSTABLE ZONE
STABLE ZONE
PARA. 2-7a (TABLE)
(ISBASH 1936)
$C_F = .9$
$C_F = .7$
$C_F = 0$
COBBLES
GRAVEL
COARSE
FINE
SAND
COARSE
MEDIUM
FINE
SILT OR CLAY
"SELF ARMORING" RIPRAP SIZES
SCOUR AND DEPOSITION BED-LOAD SIZES
SCOUR ONLY WASH-LOAD SIZES
NONCOHESIVE SEDIMENT GRADATION AND PERMISSIBLE VELOCITY
C_F = Cover Factor
minimum $\tau_a = 0.02$ psf
Particle size based on D_{75}

PLATE C-20

APPENDIX C

GEOTECHNICAL DESIGN

GRADATION CURVES



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	4.1	SM Silty gravelly sand				
3	9.3	SM Silty sand				
4	11.9	SP Sand				

Project Rochester Flood Control Project Design Memorandum No. 4

Area Bear Creek

Boring No. 89-244

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-21

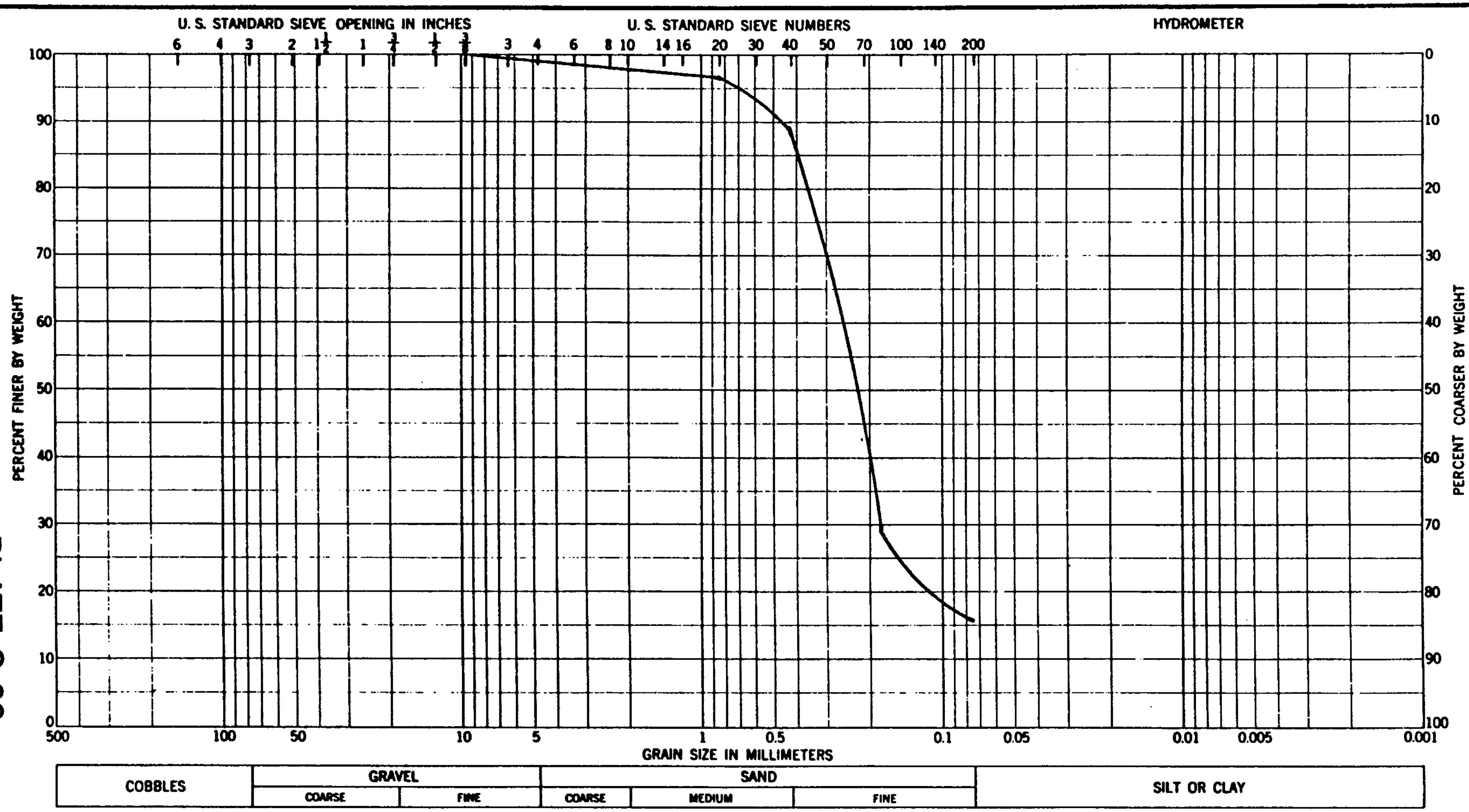


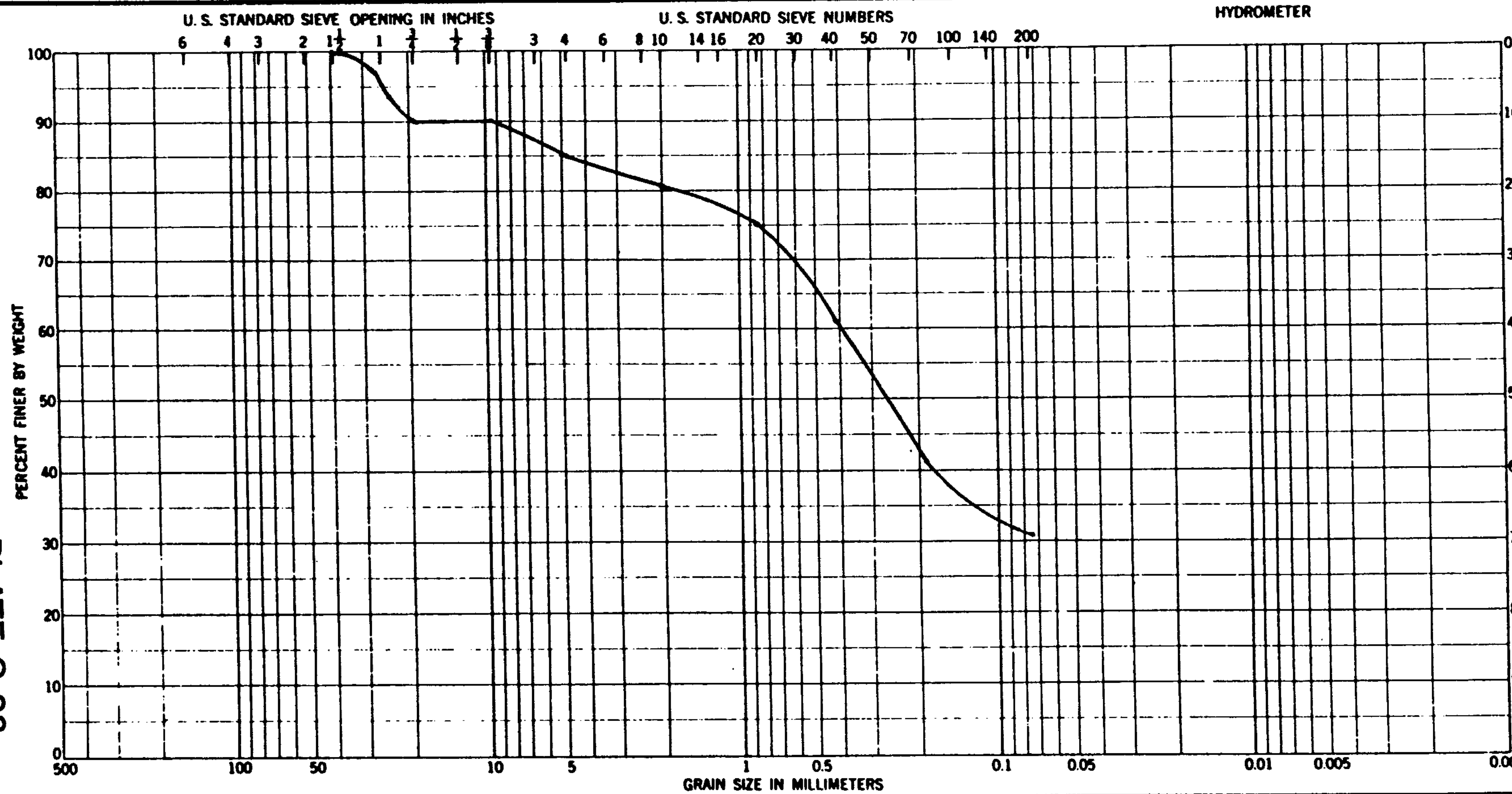
PLATE C-22

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	5.9	SM Silty Sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-245
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

PLATE C-23

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	7.0	SC Gravelly clayey Sand		24		12

Project Rochester Flood Control Project Design Memorandum No. 4

Area Bear Creek

Boring No. 89-246

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

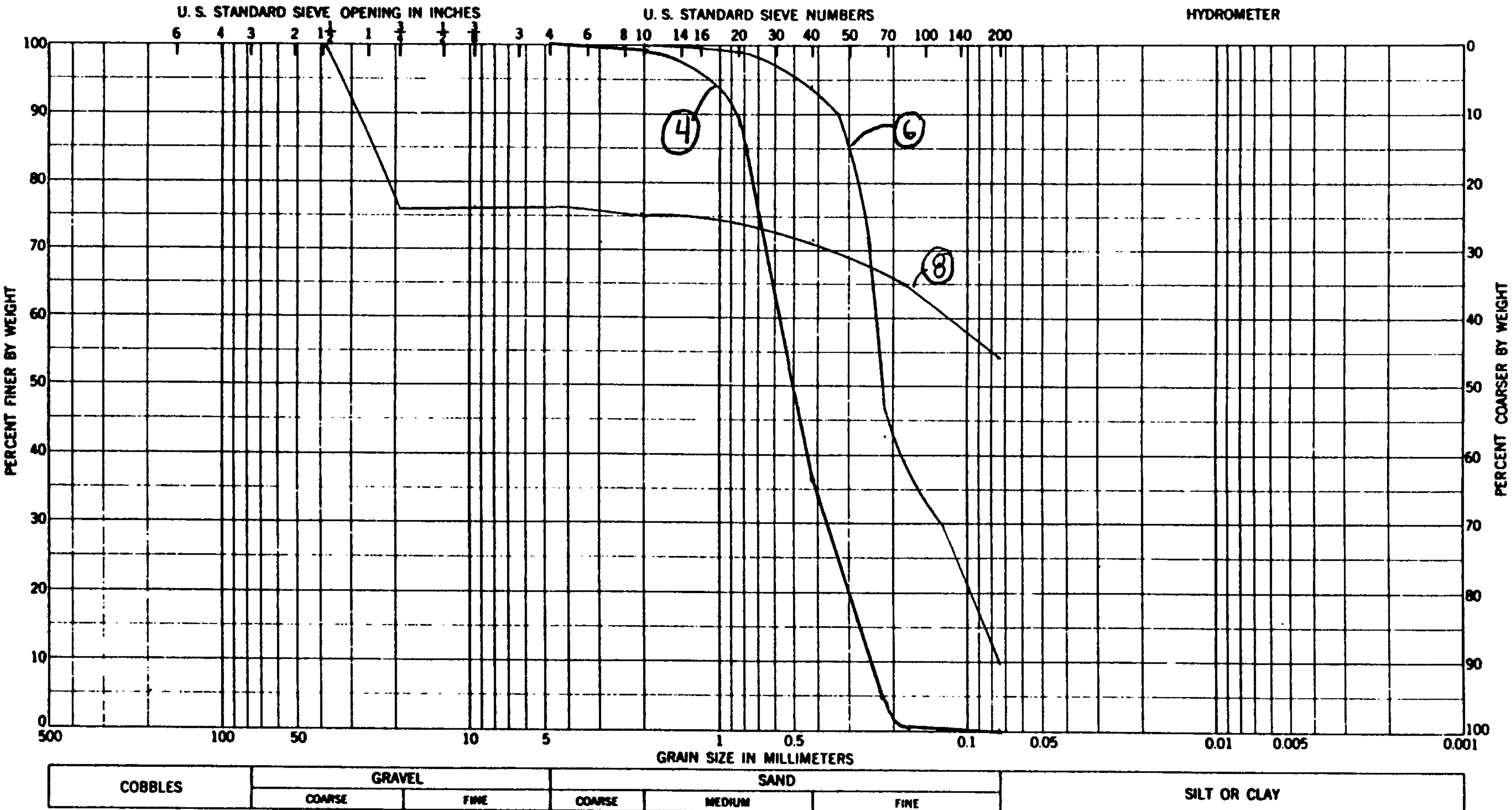


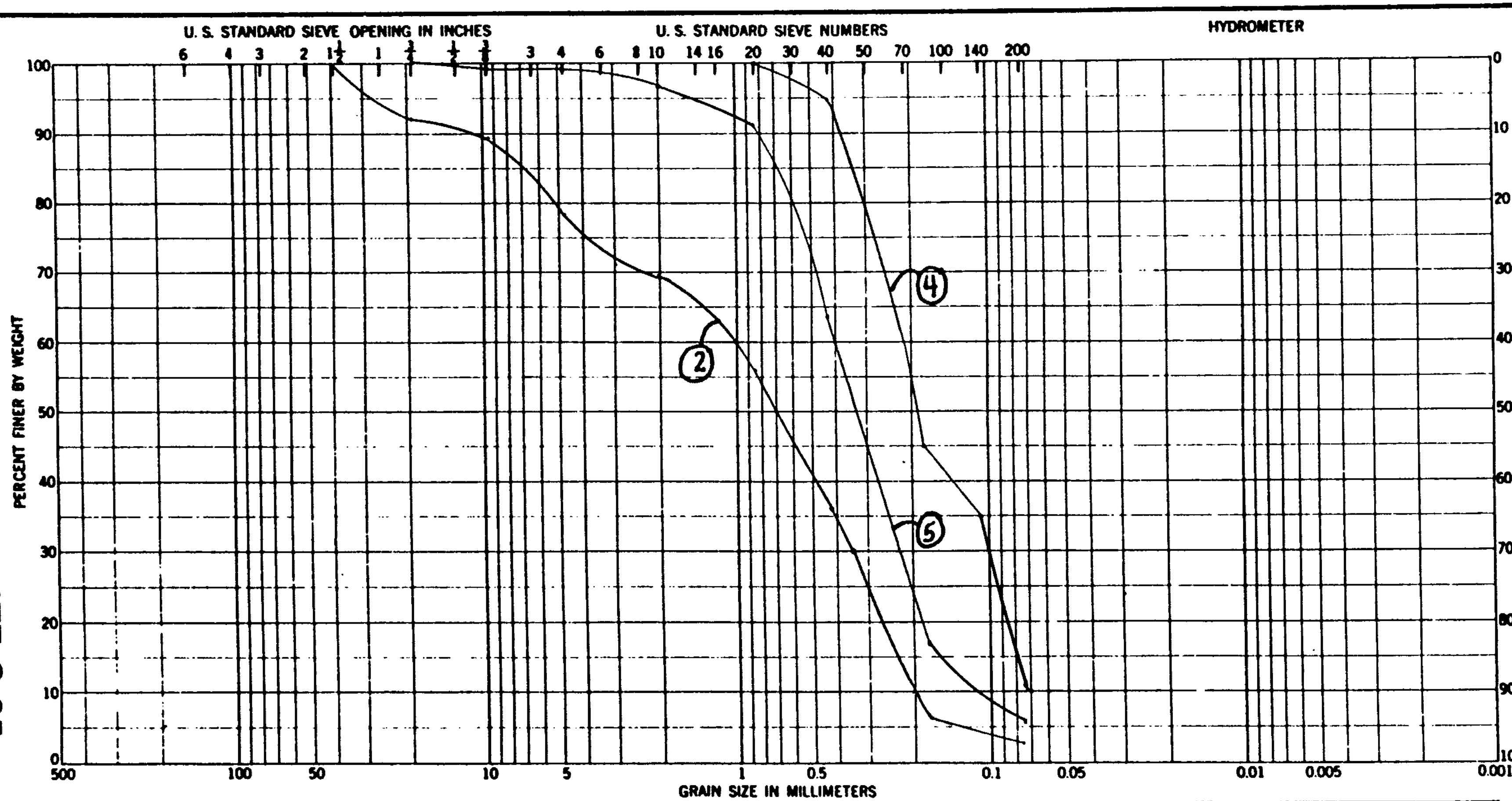
PLATE C-24

Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
4	9.4	SP	Sand				
6	19.0	SM-SP	Silty sand				
8	24.3	CL-ML	Sandy grav. clay		24		7

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-247
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	9.5	SP gravelly sand				
4	16.7	SM-SP Silty sand				
5	24.0	SM-SP Silty sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-248
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-25

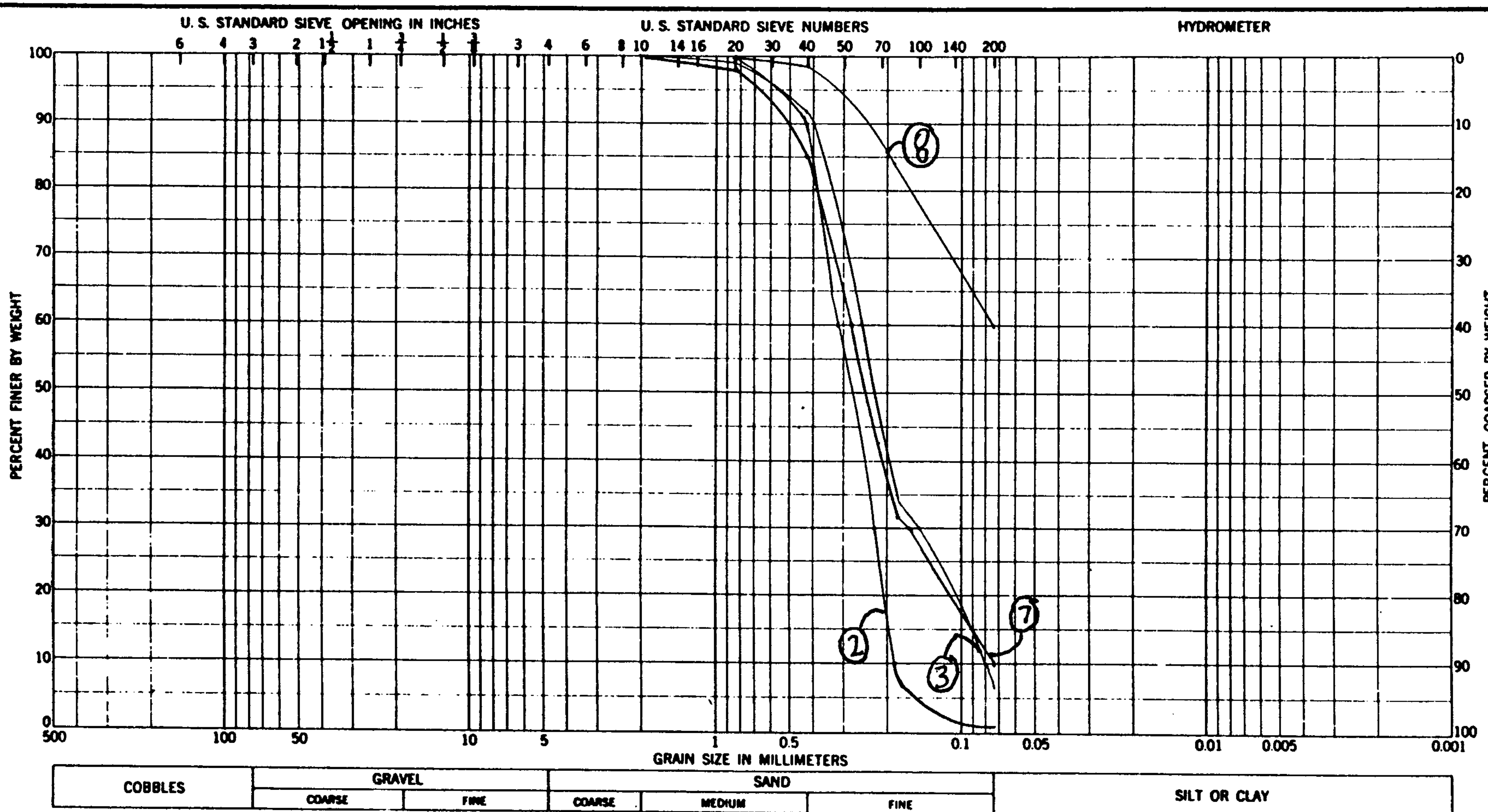


PLATE C-26

Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
2	4.8	SP	Sand				
3	8.9	SM-SP	Silty Sand				
7	21.9	SM-SP	Silty Sand				
8	25.5	CL	Sandy Clay		27		17

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-249
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

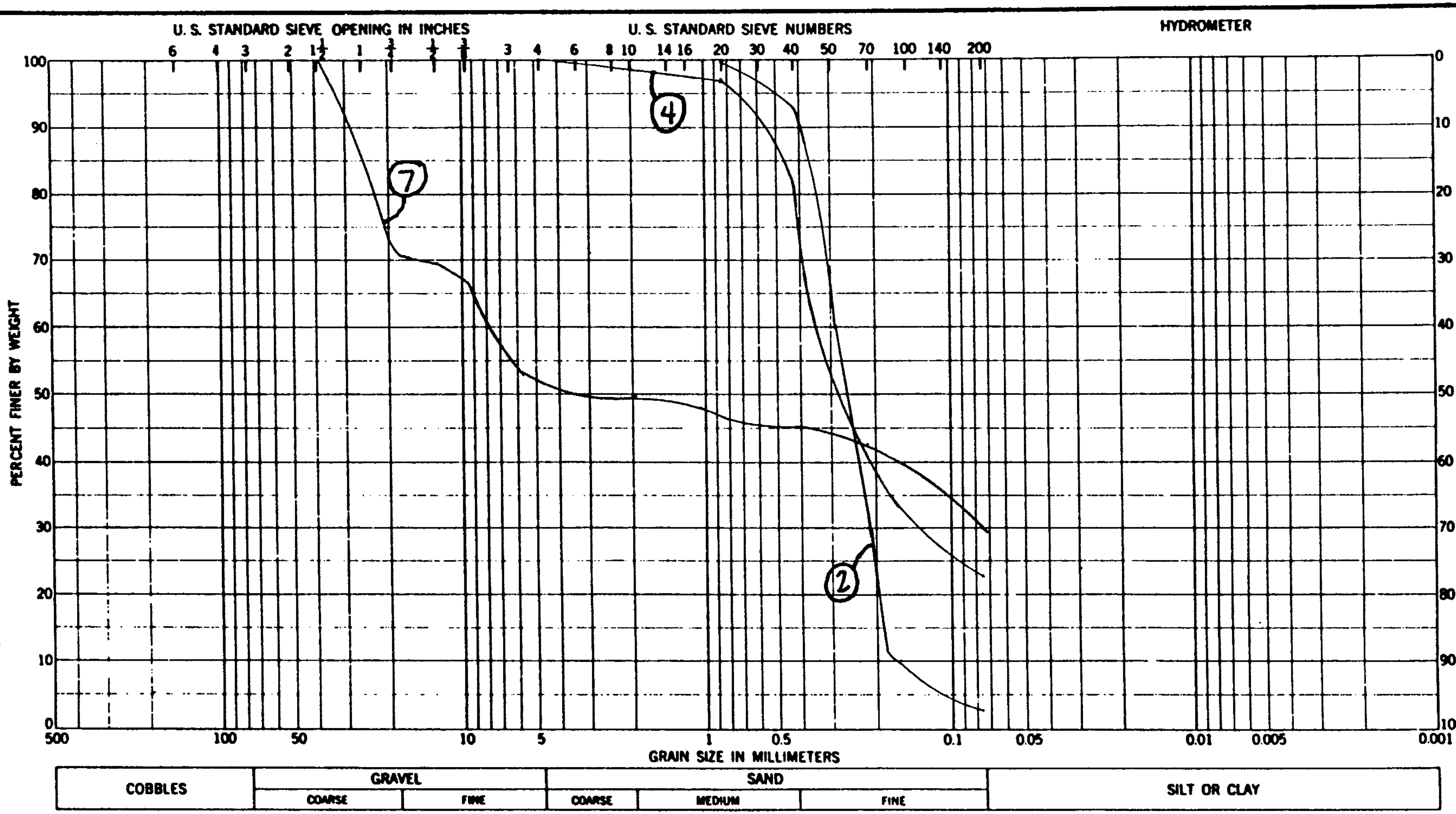


PLATE C-27

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	4.2	SP Sand				
4	14.5	SM Silty Sand				
7	25.0	GM Silty Sand gravel				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-250
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

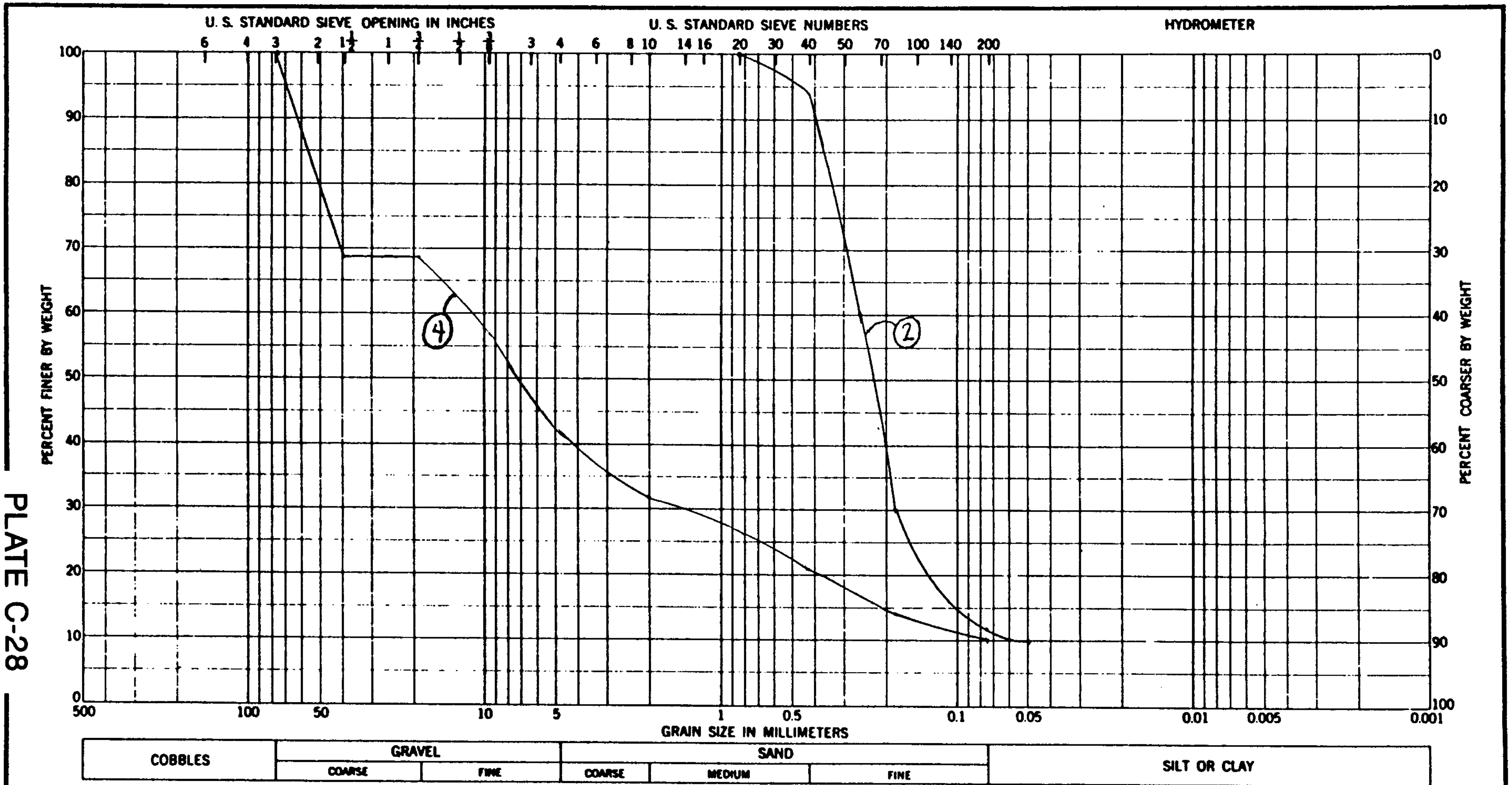


PLATE C-28

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	4.2	SM-SP Silty sand				
4	10.9	GM Silty sandy gravel				

Project Rochester Flood Control Project Design Memorandum No. 4

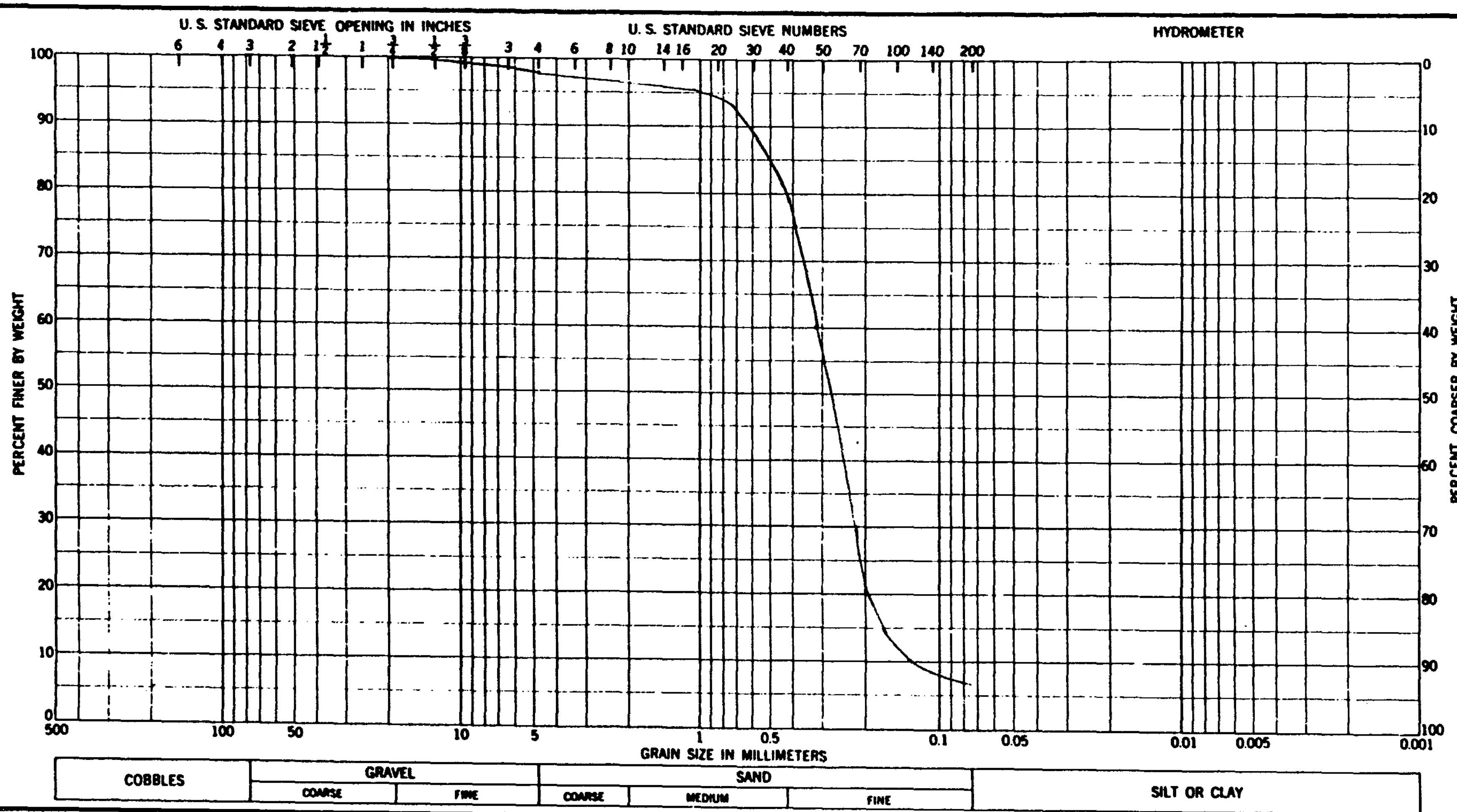
Area Bear Creek

Boring No. 89-251

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	10.5	SM-SP Silty Sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-252
Date

GRADATION CURVES

PLATE C-29

ENG FORM 1 MAY 63 2087

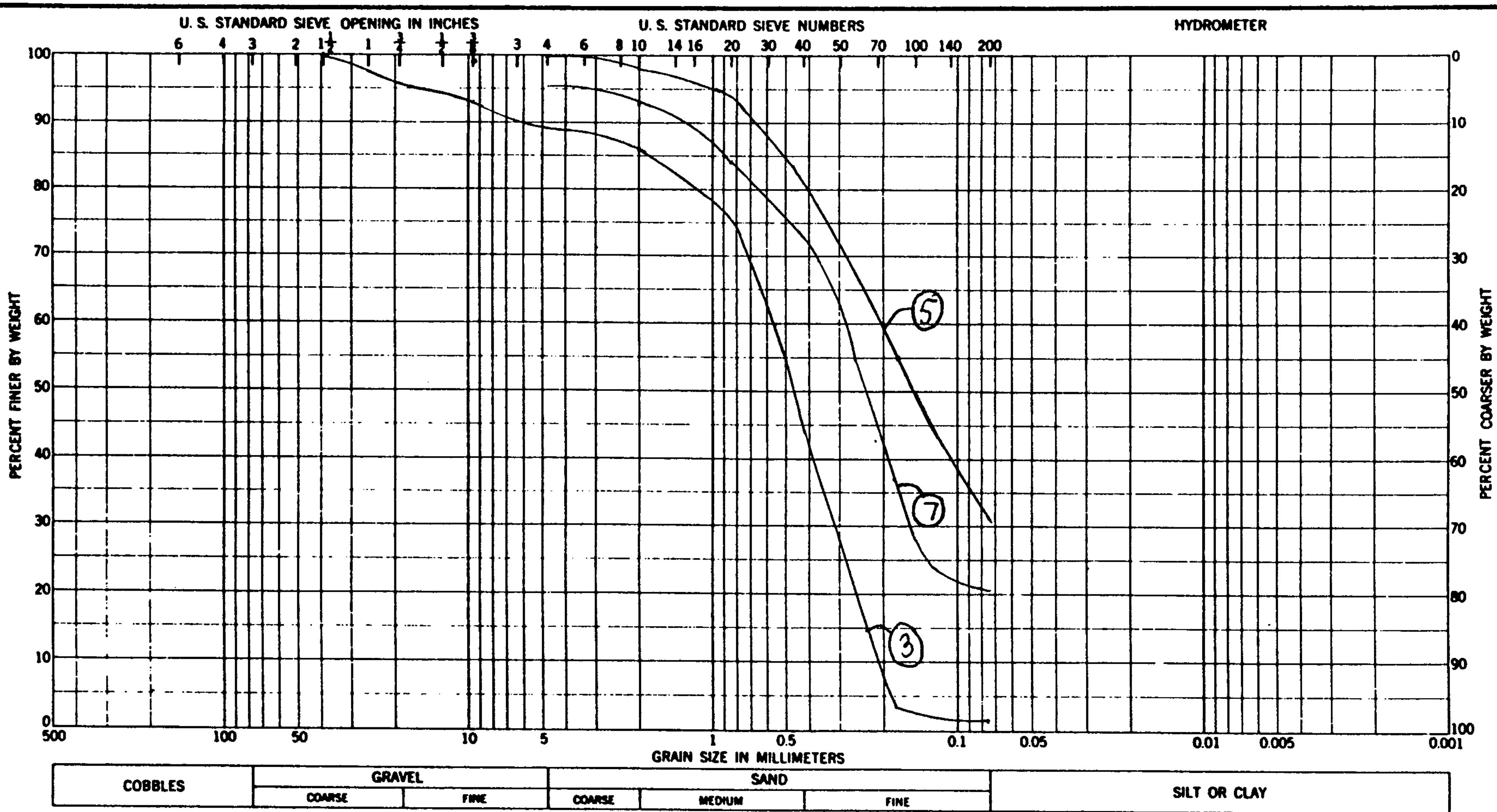


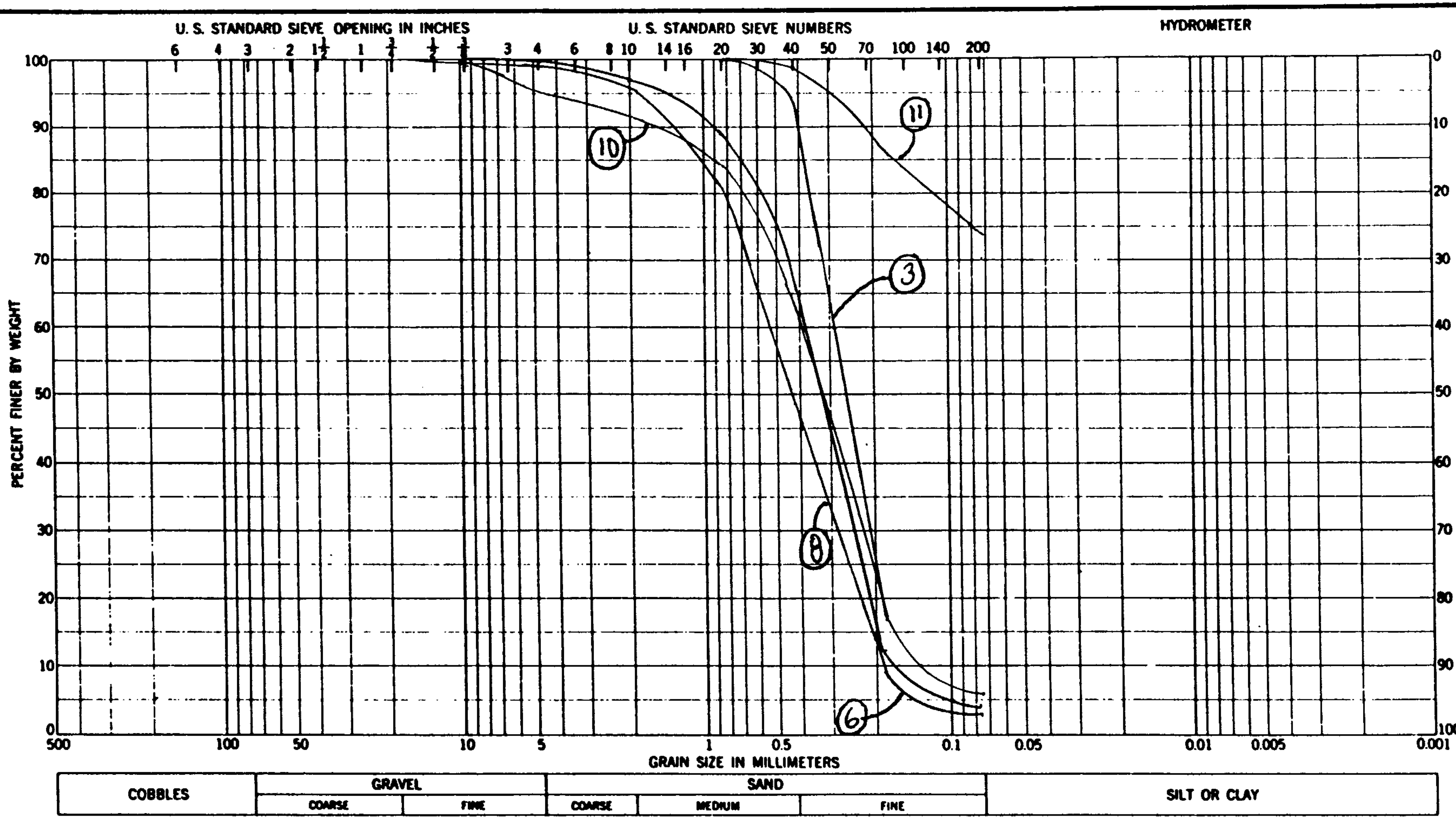
PLATE C-30

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	7.1	SP Sand				
5	14.9	SM Silty Sand				
7	21.3	SM Silty Sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-253
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	5.0	SM-SP Silty Sand				
6	14.5	SP Sand				
8	24.0	SP Sand				
10	33.2	SM-SP Silty Sand				
11	35.2	CL-ML Sandy Clay		22		6

Project Rochester Flood Control Project
Design Memorandum No. 4

Area Bear Creek

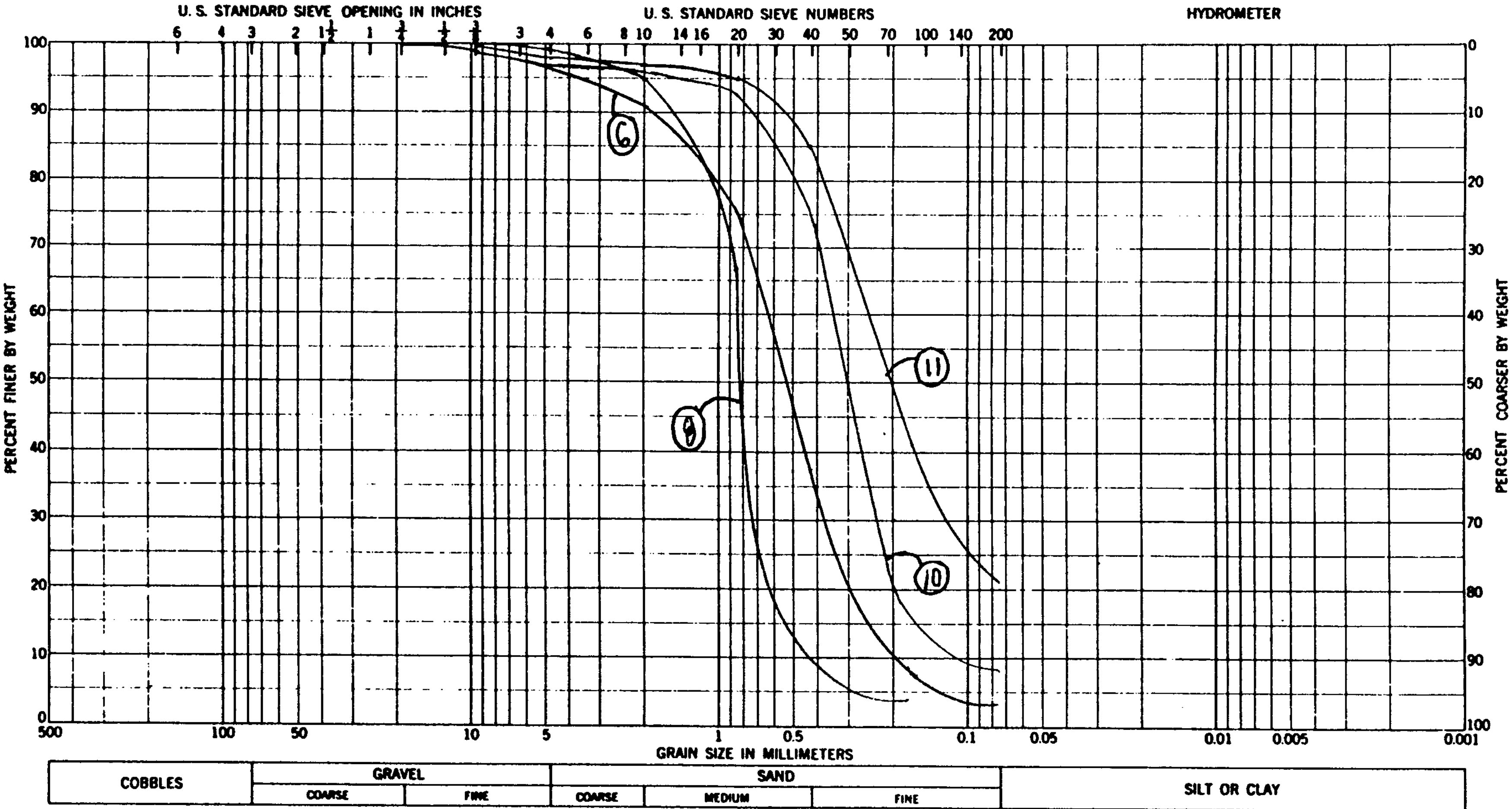
Boring No. 89-254

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-31



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
6	14.0	SP Sand				
8	24.0	SP Sand				
10	34.0	SM-SP Silty Sand				
11	35.6	SM Silty sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-255
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-32

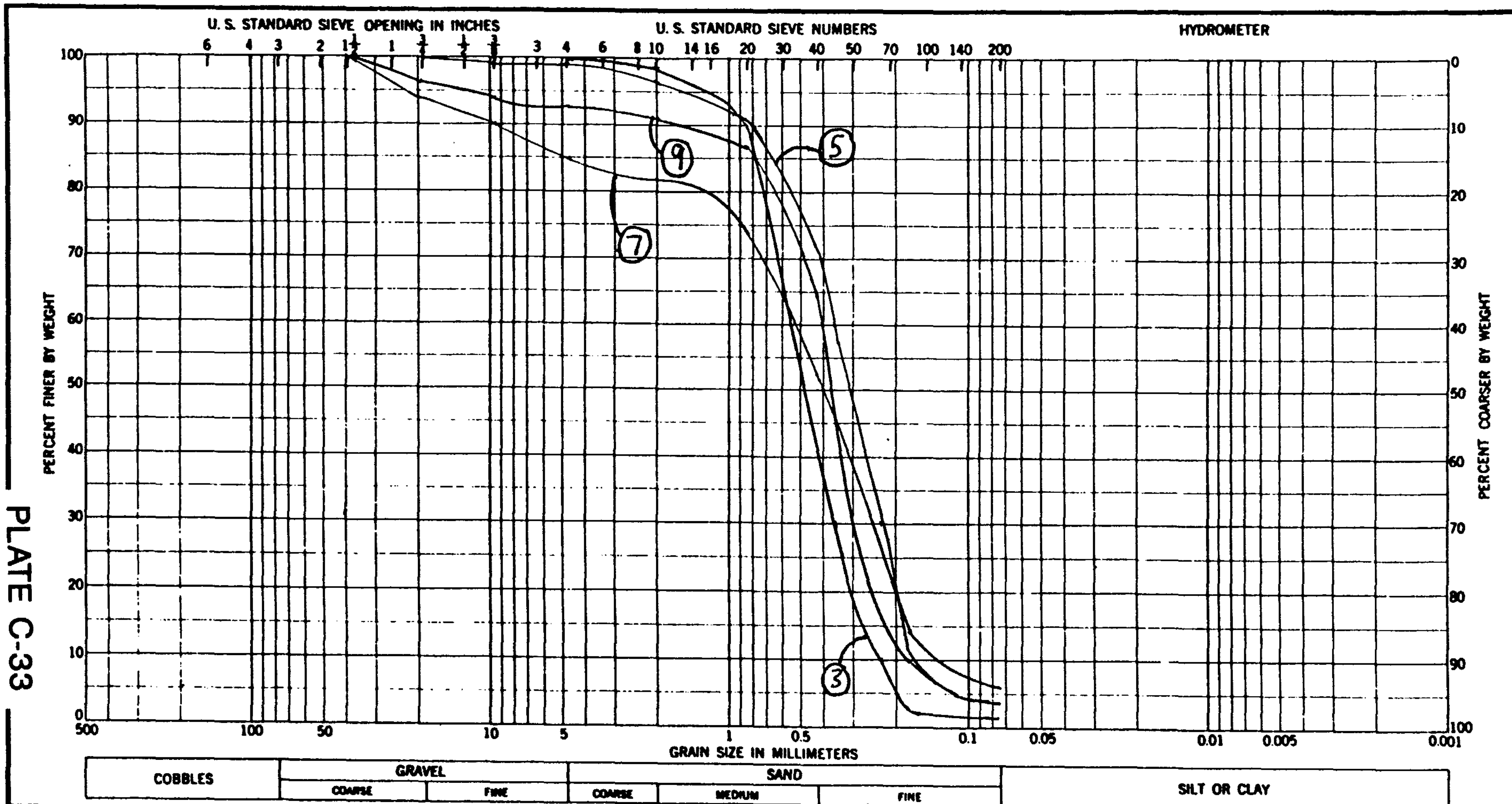


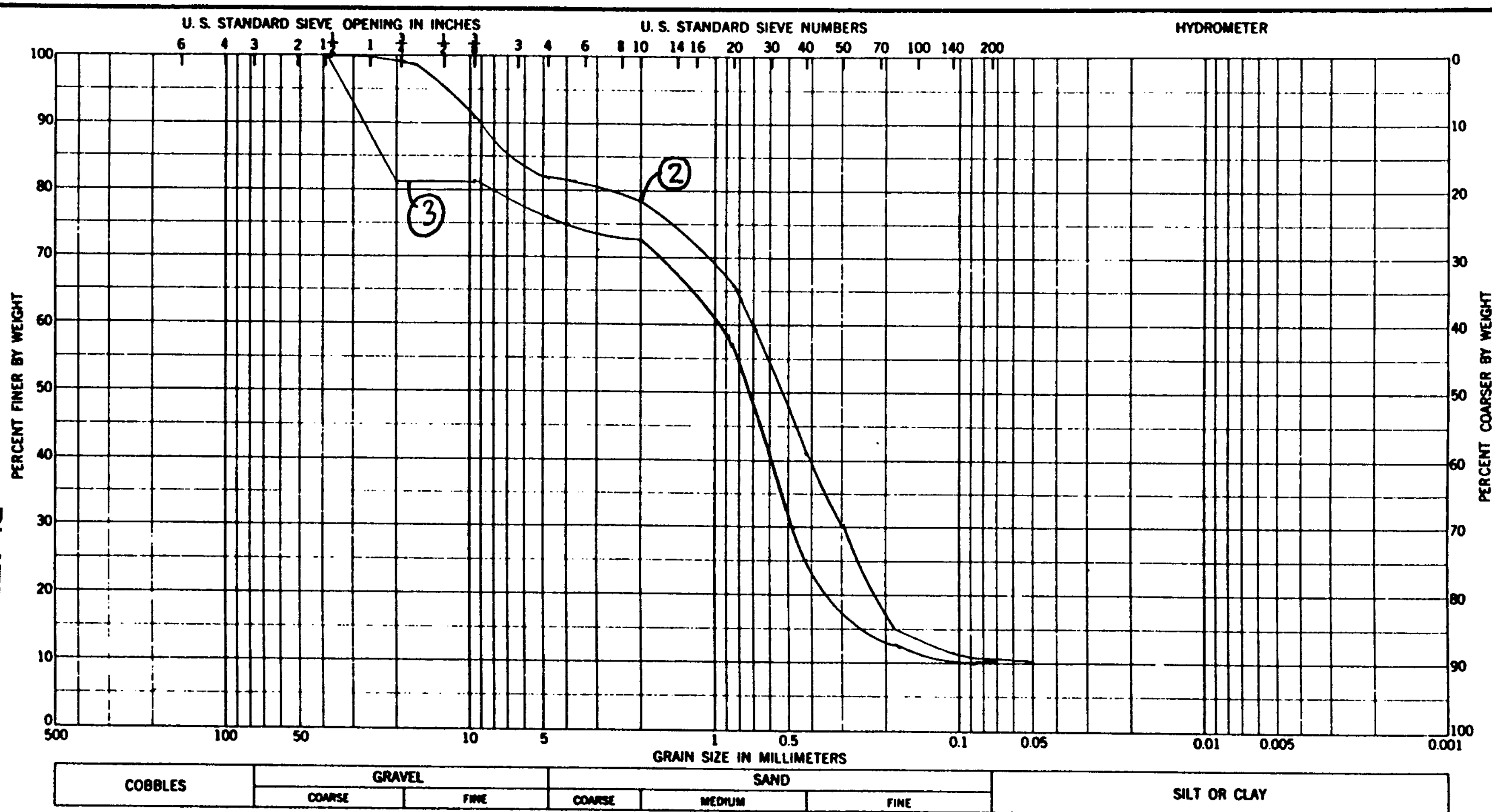
PLATE C-33

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	6.5	SP Sand				
5	19.0	SP Sand				
7	27.1	SM-SP Silty grav. sand				
9	39.0	SP Sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-256
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



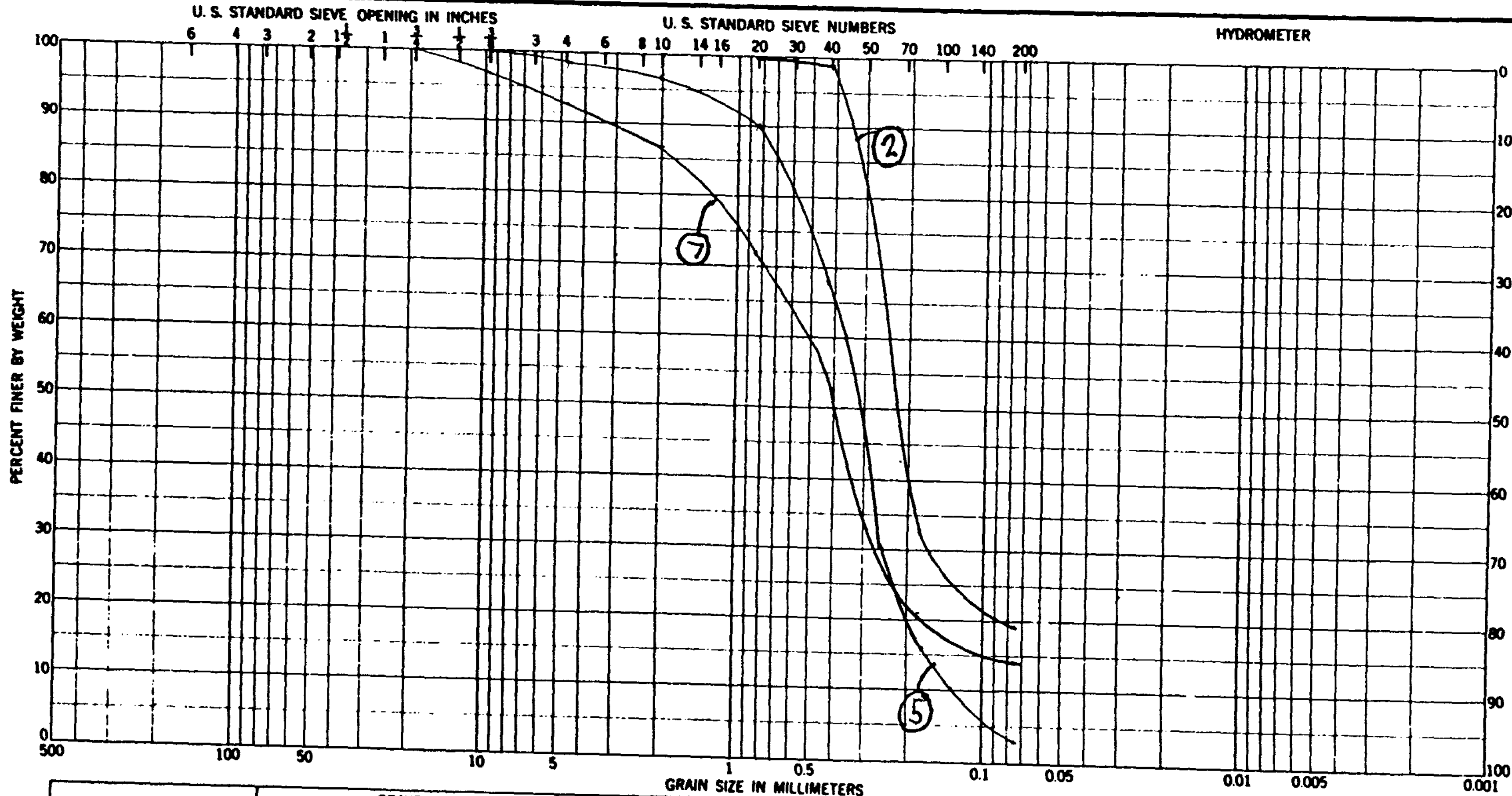
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	6.9	SM-SW Silty grav. sand				
3	10.9	SM-SW Silty grav. sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-257
Date

GRADATION CURVES

PLATE C-34

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	1.9	SM Silty Sand				
5	11.7	SP Sand				
7	19.4	SM Silty Sand				

Project Rochester Flood Control Project Design Memorandum No. 4

Area Bear Creek

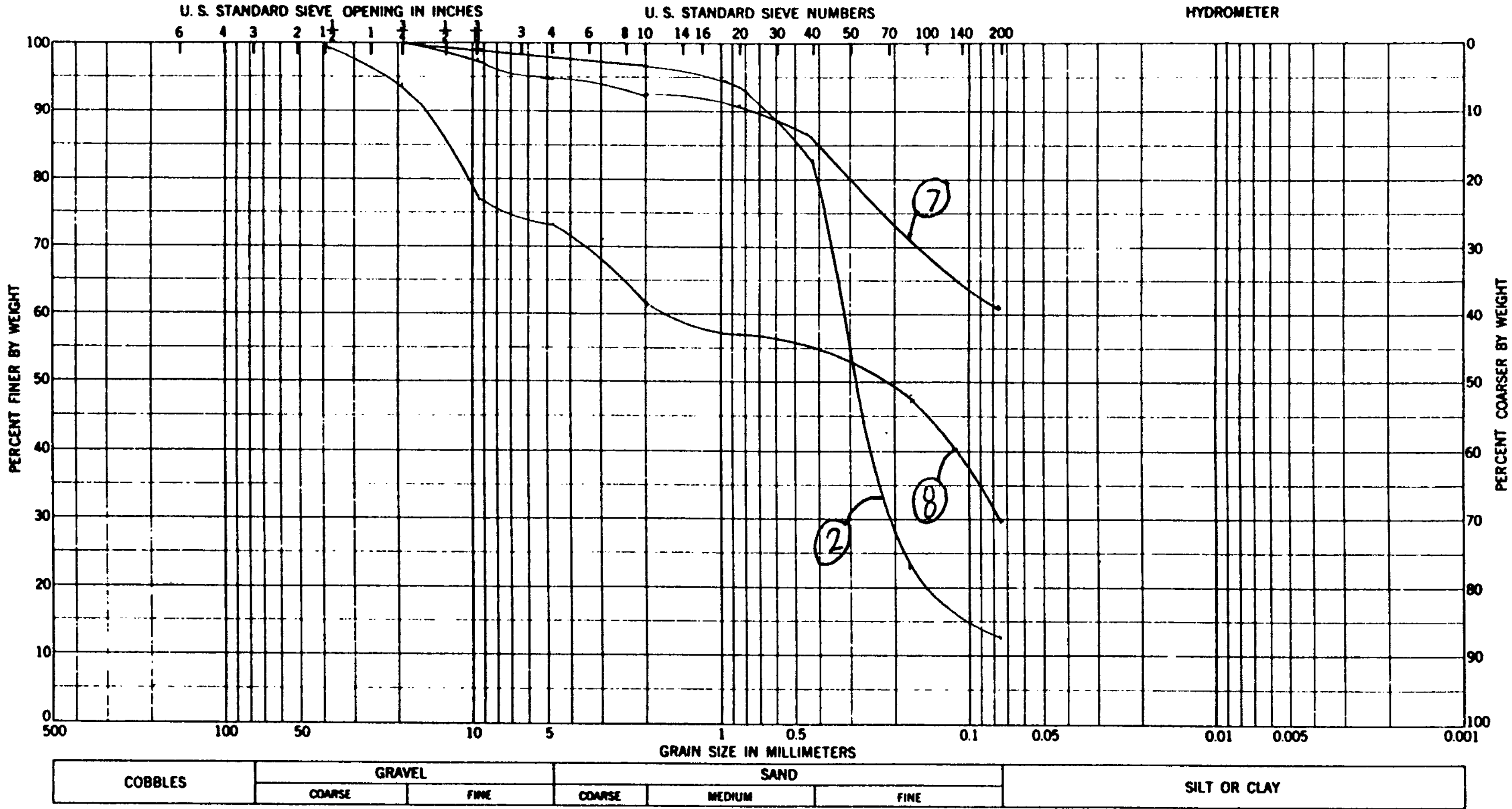
Boring No. 89-258

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-35



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
2	2.1	SM	Silty sand				
7	21.6	CL-ML	Sandy Clay		16		6
8	24.9	SM	Gravelly silty sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-259
Date

GRADATION CURVES

PLATE C-36

ENG FORM 1 MAY 63 2087

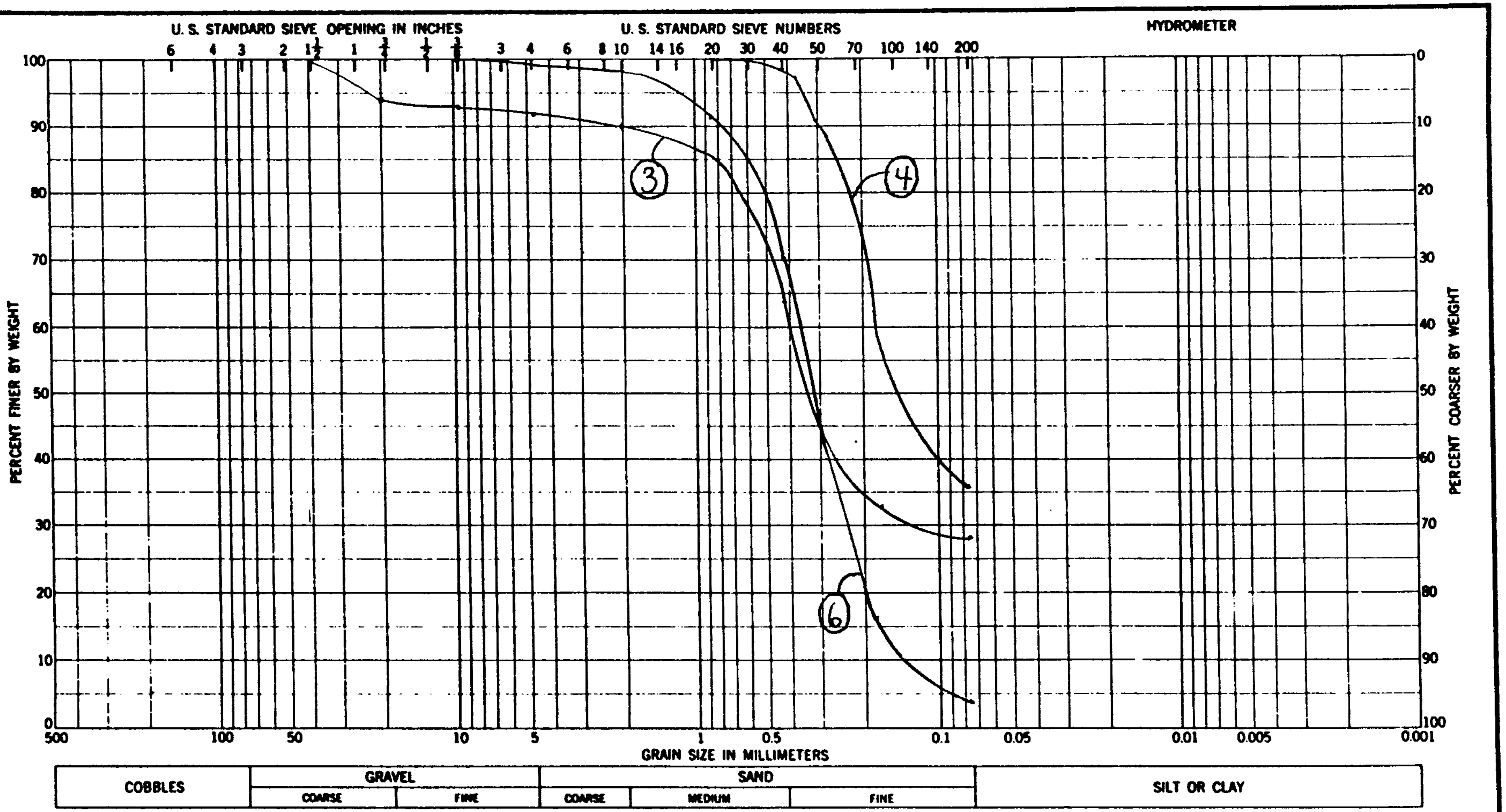


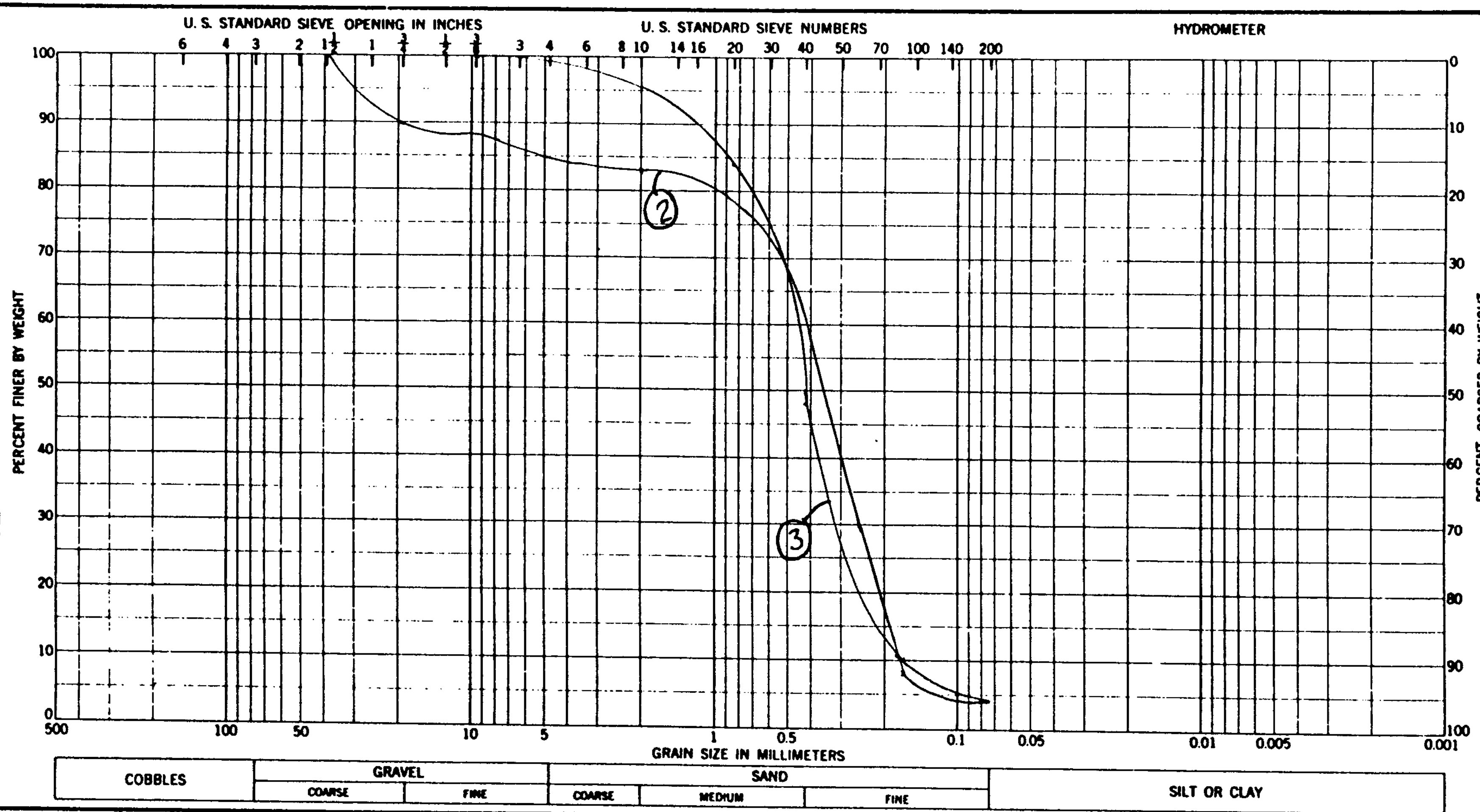
PLATE C-37

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	6.7	SM Silty Sand				
4	9.9	SM Silty Sand				
6	16.5	SP Sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-260
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	5.9	SP Gravelly sand				
3	9.8	SP Sand				

Project Rochester Flood Control Project
Design Memorandum No. 4

Area Bear Creek

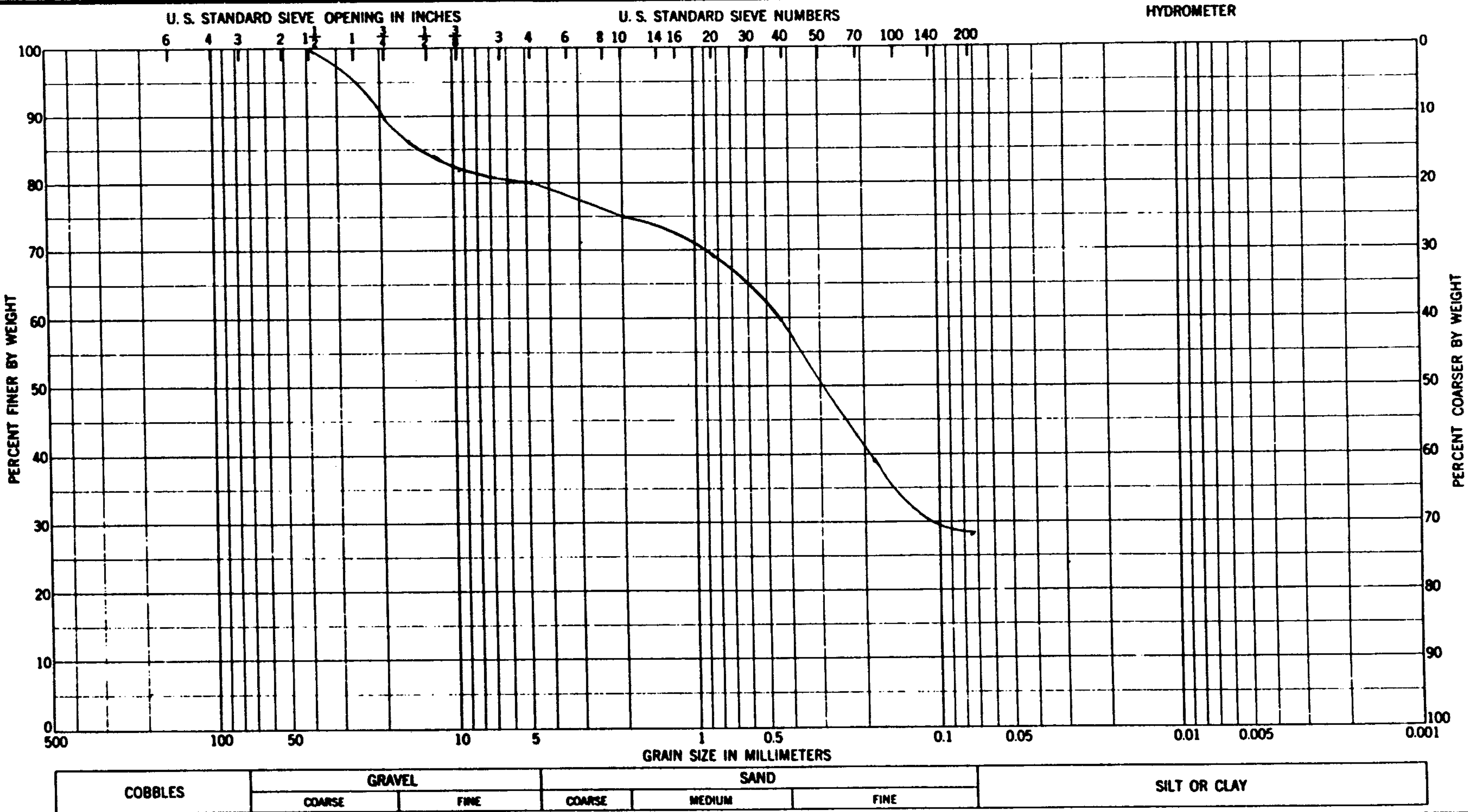
Boring No. 89-261

Date

GRADATION CURVES

PLATE C-38

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	5.7	SC Gravelly clayey Sand		22		10

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-263
Date

GRADATION CURVES

PLATE C-39

ENG FORM 1 MAY 63 2087

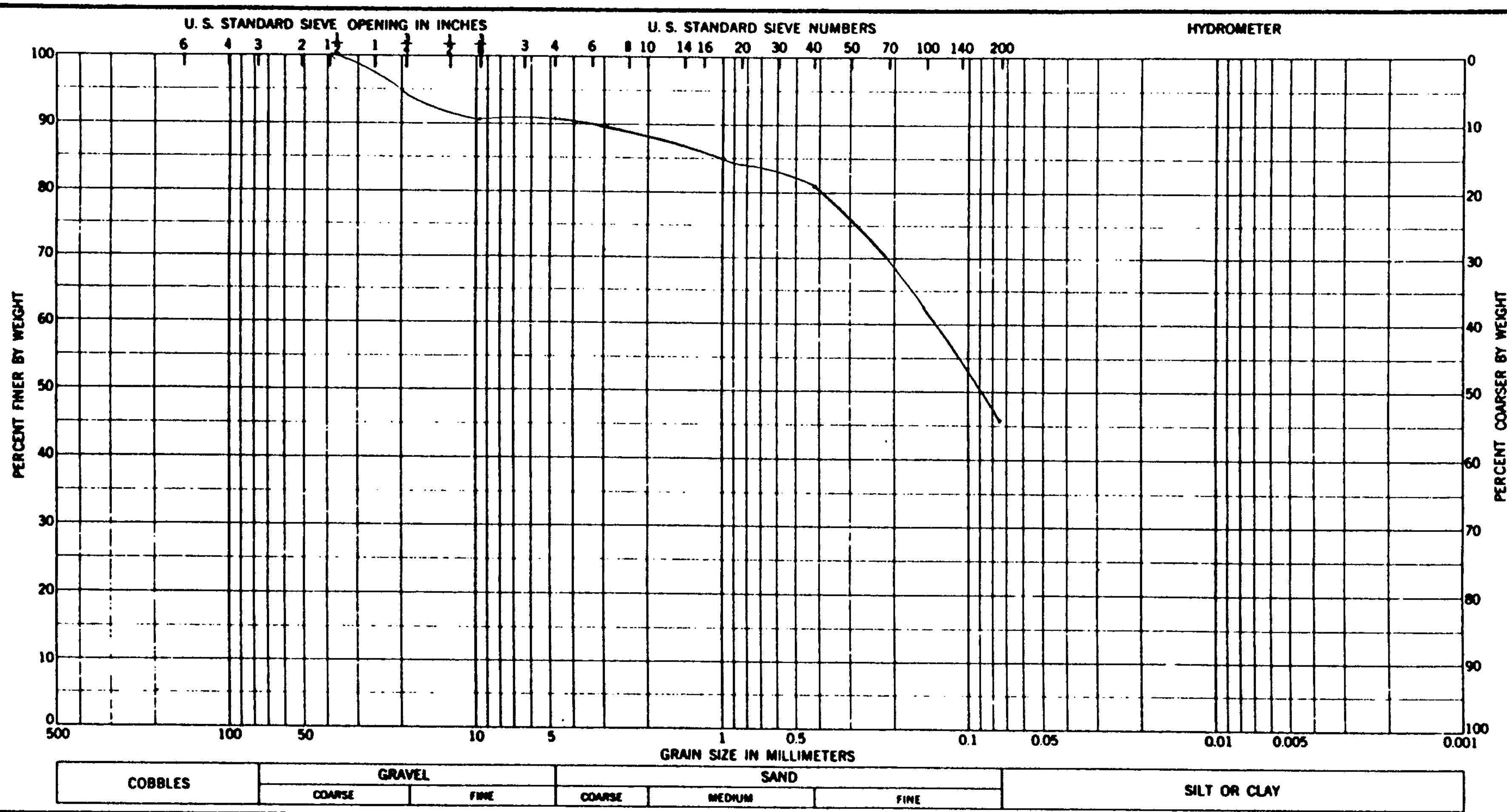


PLATE C-40

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	5.7	SC Clayey sand		41		24

Project Rochester Flood Control Project
Design Memorandum No. 4

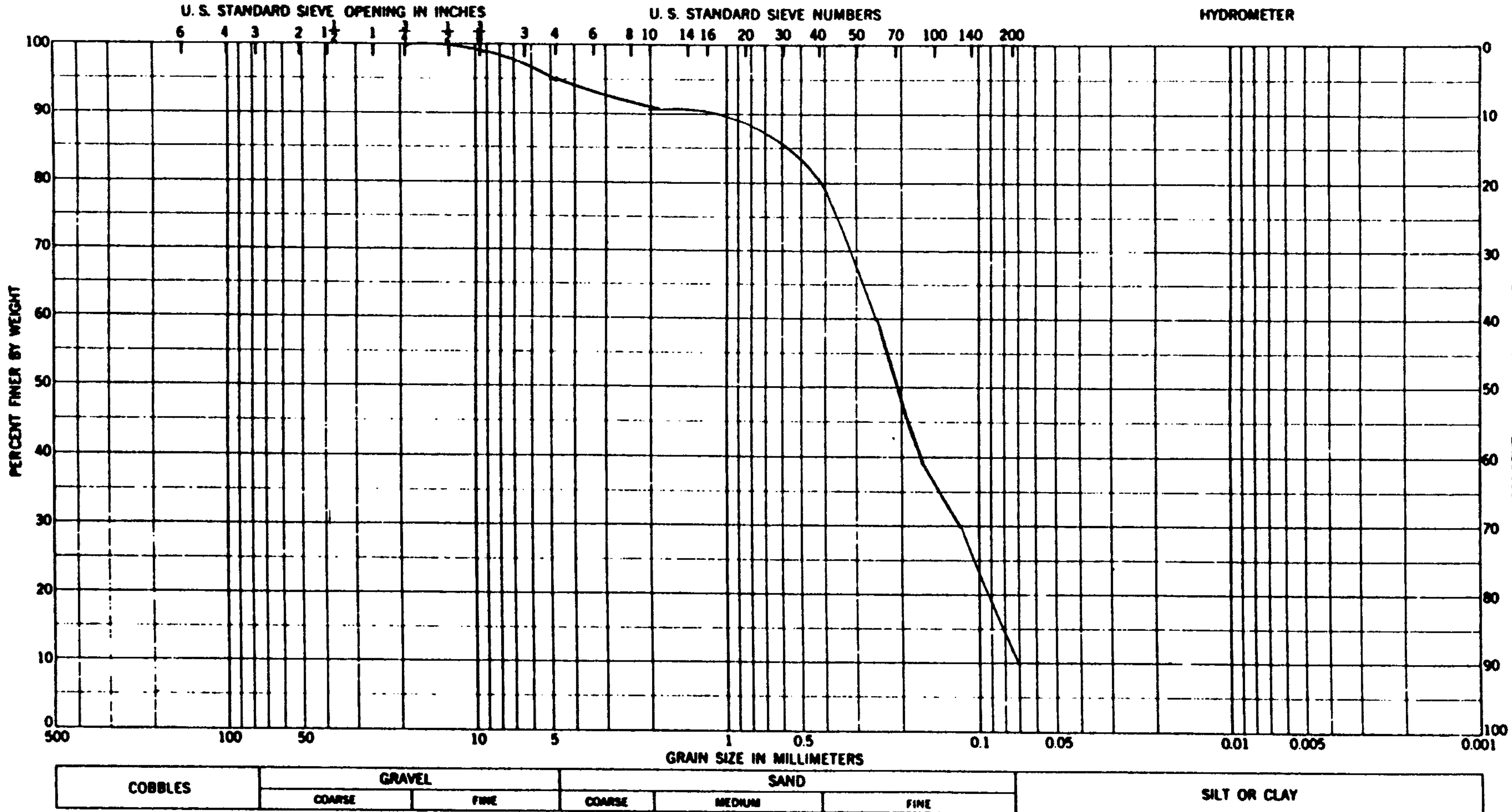
Area Bear Creek

Boring No. 89-266

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	6.6	SM-SP silty sand				

Project Rochester Flood Control Project Design Memorandum No. 4

Area Bear Creek

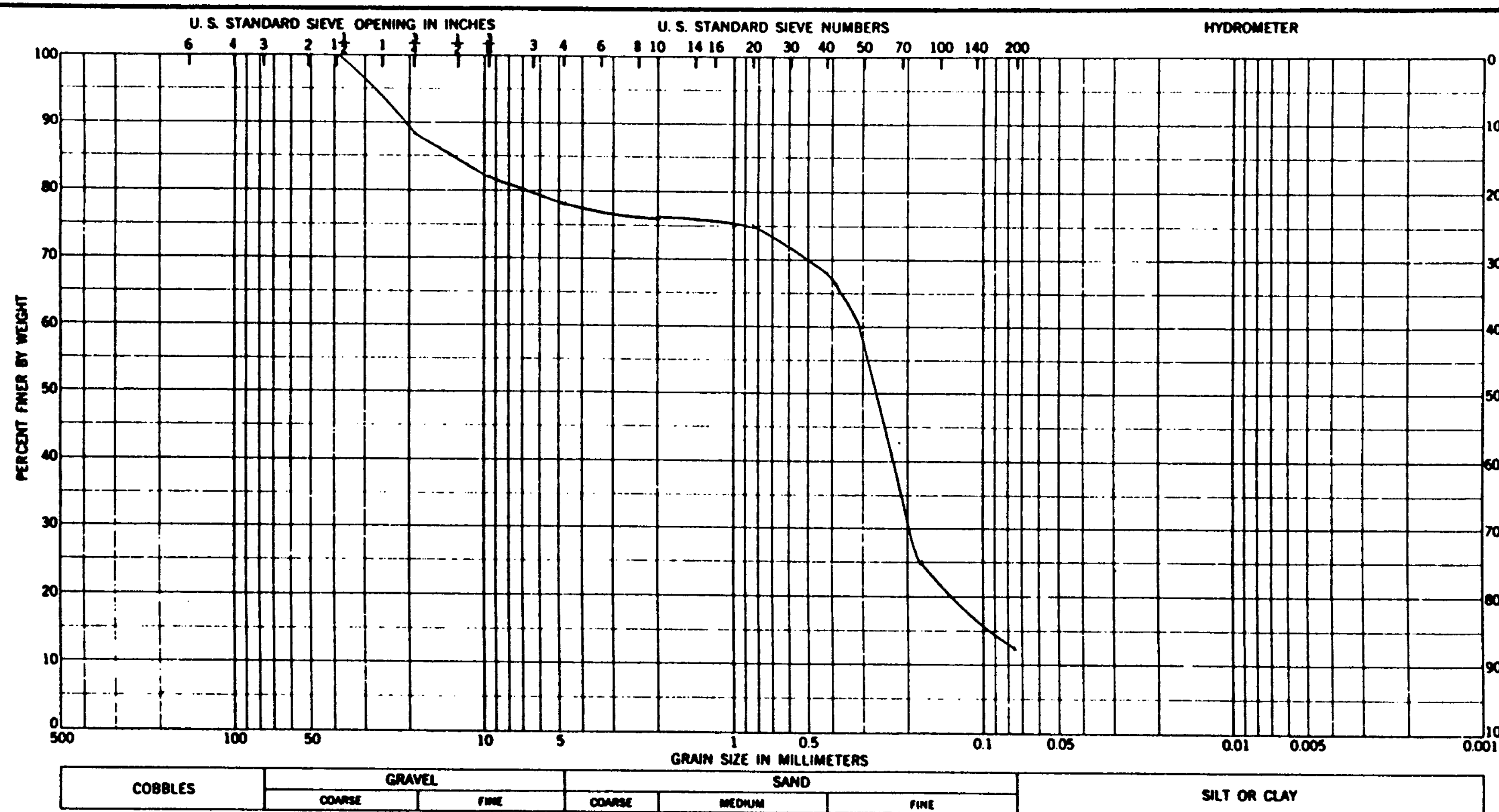
Boring No. 89-267

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-41



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	4.0	SM Silty gravelly sand				

Project Rochester Flood Control Project Design Memorandum No. 4

Area Bear Creek

Boring No. 89-269

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-42

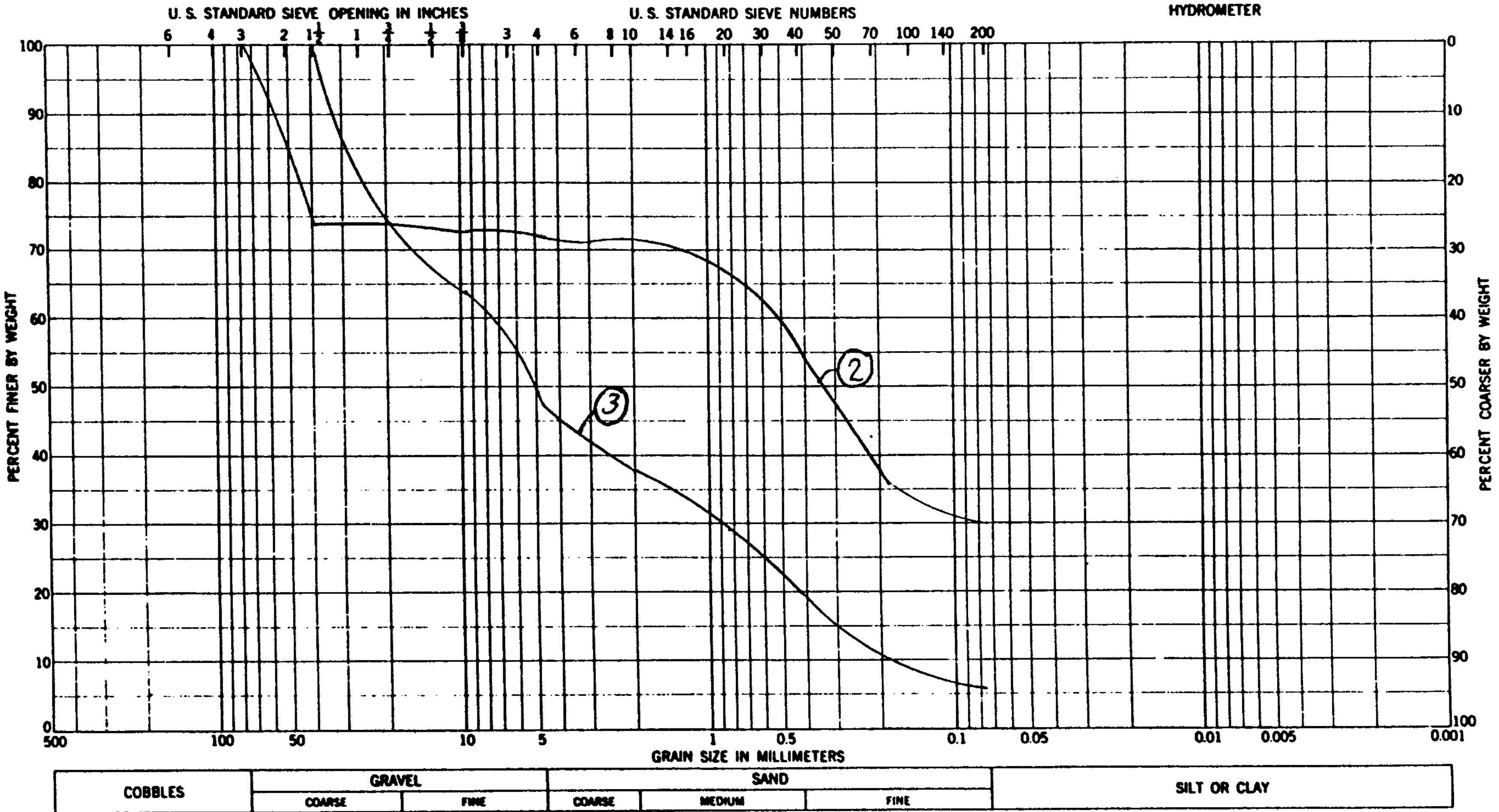


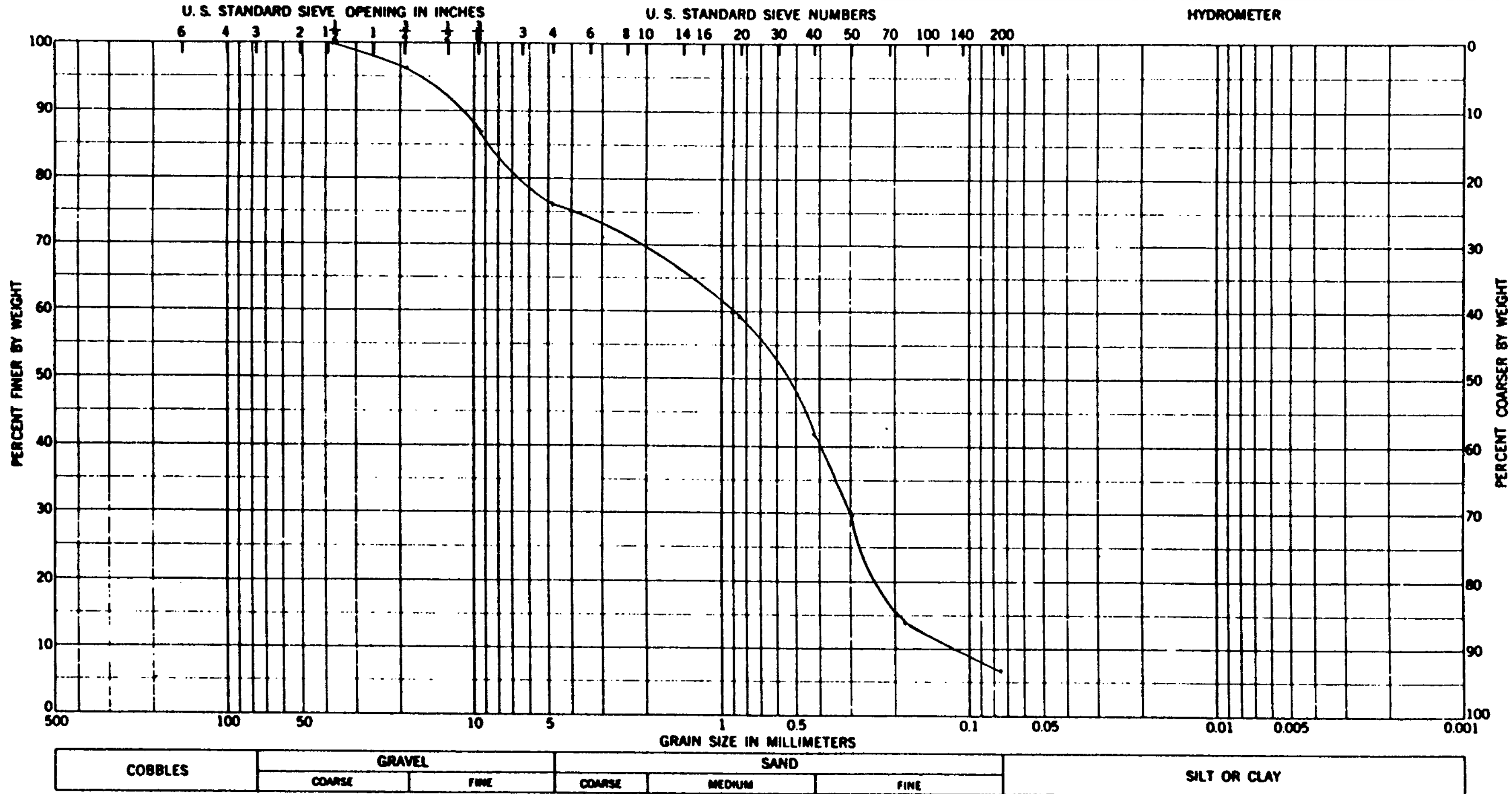
PLATE C-43

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2		SC Gravelly clayey sand		25		12
3		GM-GP Silty sandy gravel				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-270
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087



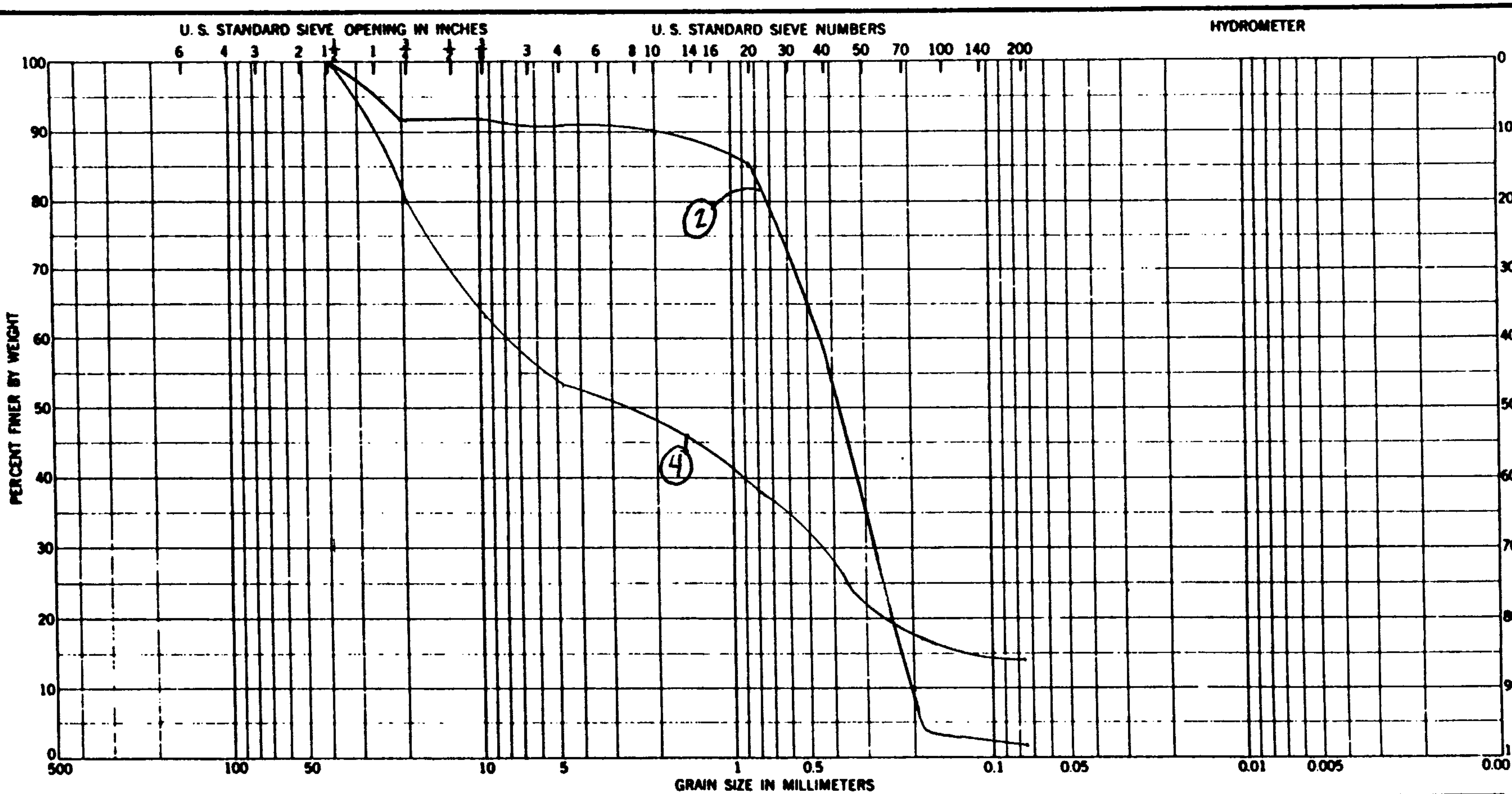
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	7.1	SM-SP Silty grav. sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-271
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-44



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

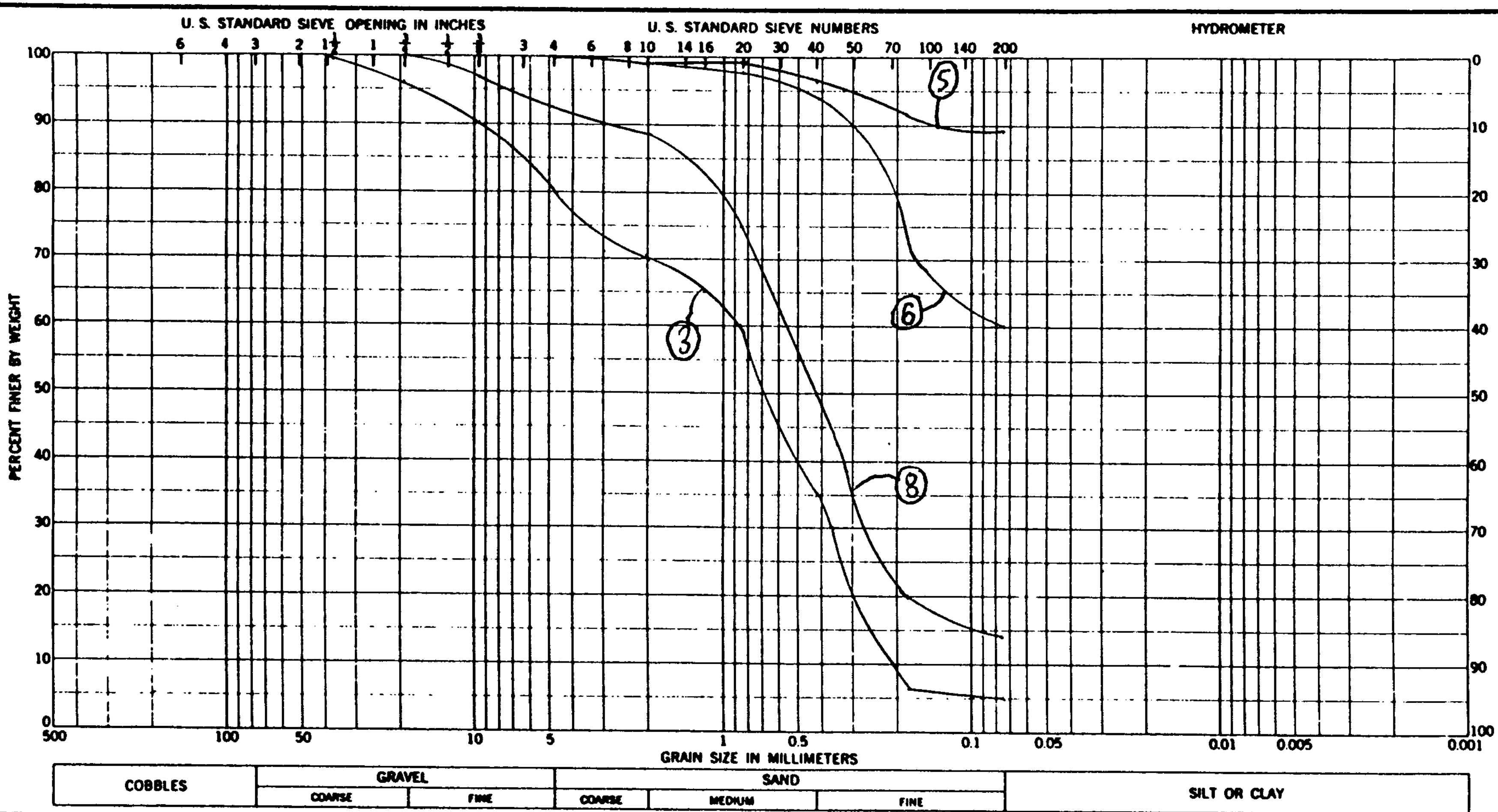
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	6.8	SP Sand				
4	14.5	GM Silty sandy gravel				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-272
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-45



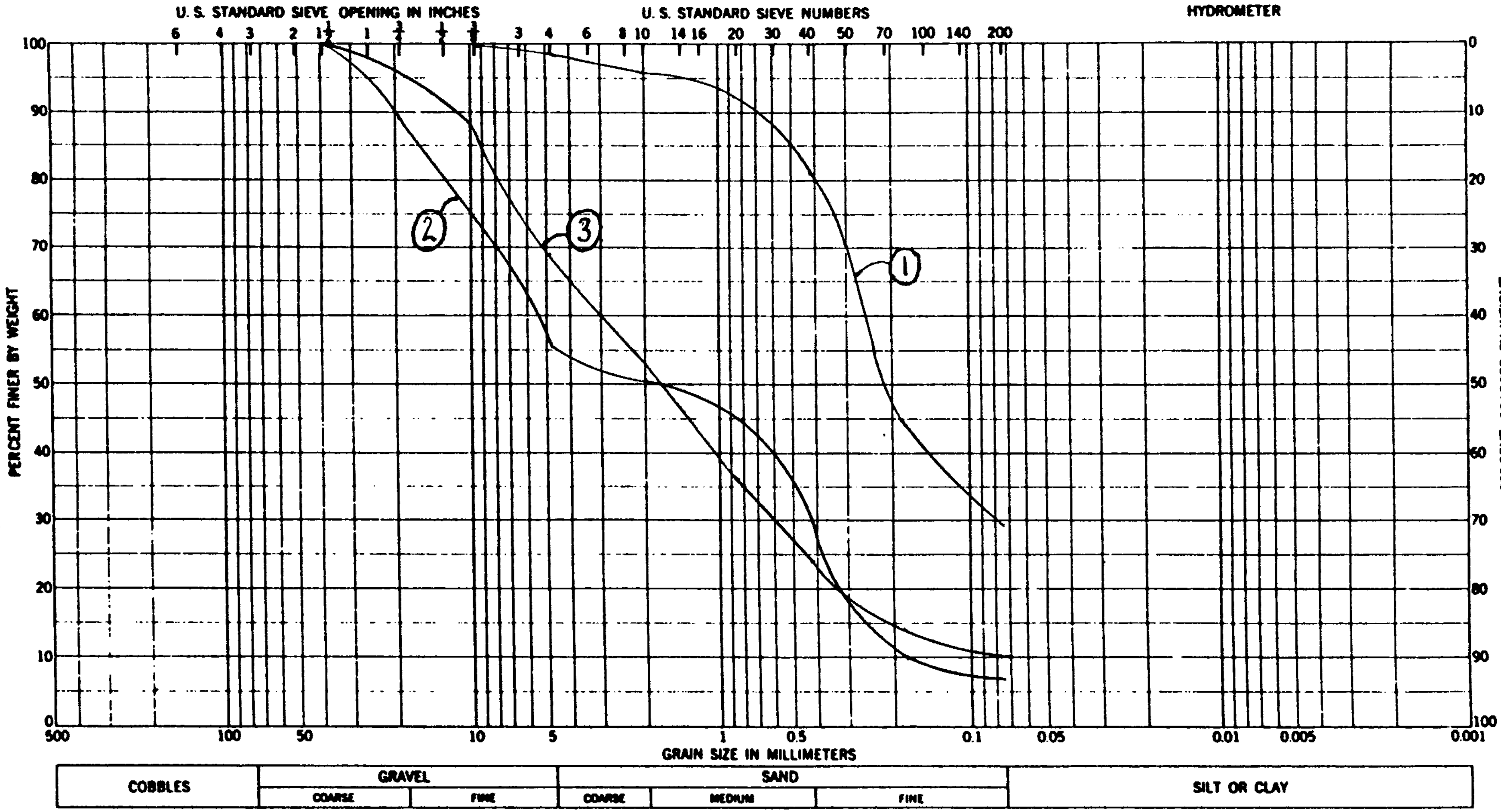
Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	6.7	SM-SP Silty grav. sand				
5	15.9	CL Sandy clay		44		25
6	20.7	CL Sandy clay		38		23
8	26.9	SM Silty sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-273
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-46



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	4.1	SM silty sand				
2	5.9	SM-SP silty grav. sand				
3	8.3	SM-SW silty grav. sand				

Project Rochester Flood Control Project Design Memorandum No. 4

Area Bear Creek

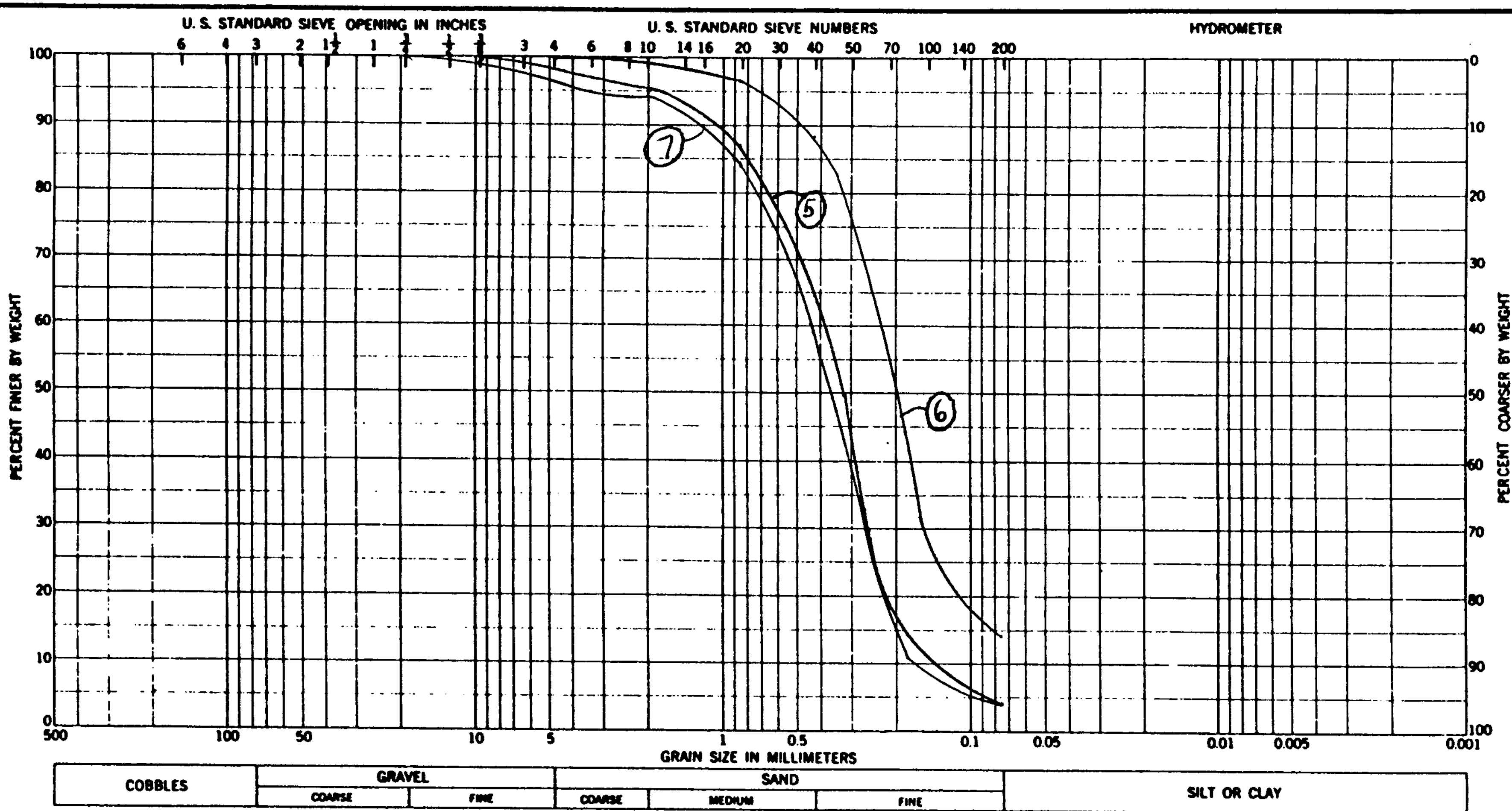
Boring No. 89-274

Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

PLATE C-47



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	17.1	SP Sand				
6	22.2	SM Silty sand				
7	25.9	SP Sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-275
Date

GRADATION CURVES

PLATE C-48

ENG FORM 1 MAY 63 2087

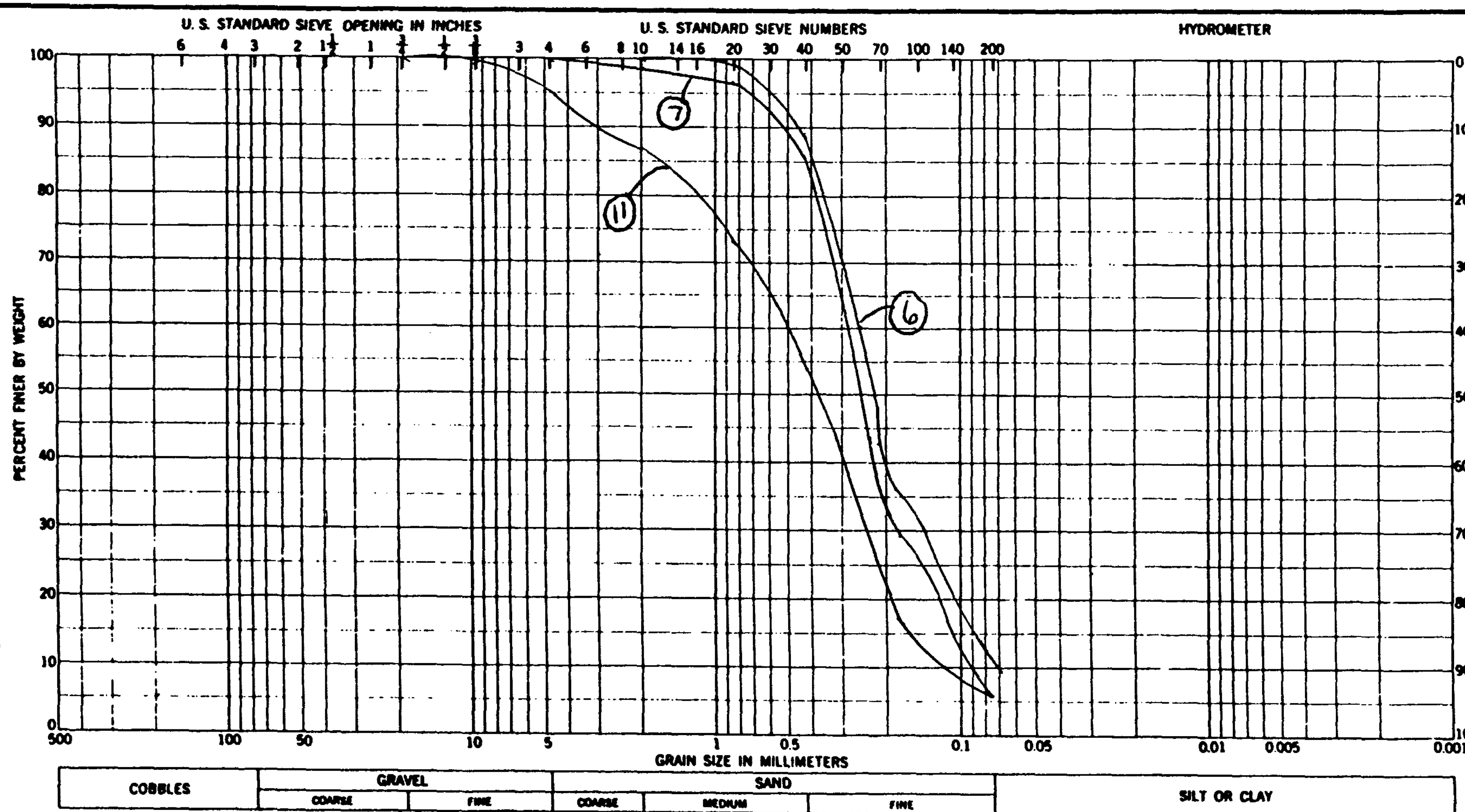


PLATE C-49

Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
6	16.9	SM-SP	Silty sand				
7	19.2	SM-SP	Silty sand				
11	36.9	SM-SP	Silty sand				

Project Rochester Flood Control Project
Design Memorandum No. 4
Area Bear Creek
Boring No. 89-276
Date

GRADATION CURVES

ENG FORM 1 MAY 63 2087

APPENDIX C

GEOTECHNICAL DESIGN

COMPUTATIONS FOR UPSTREAM DROP STRUCTURE

SUBJECT: Upstream Drop Structure	COMPUTED BY: DAC	DATE: 1/27/92	FILE NO. ROCH DM 6
	CHECKED BY:	DATE:	SHEET NO. 1

Sand Permeability at U/S Drop Structure

D_{10} Grain Size Tests at Near-by Borings [mm]

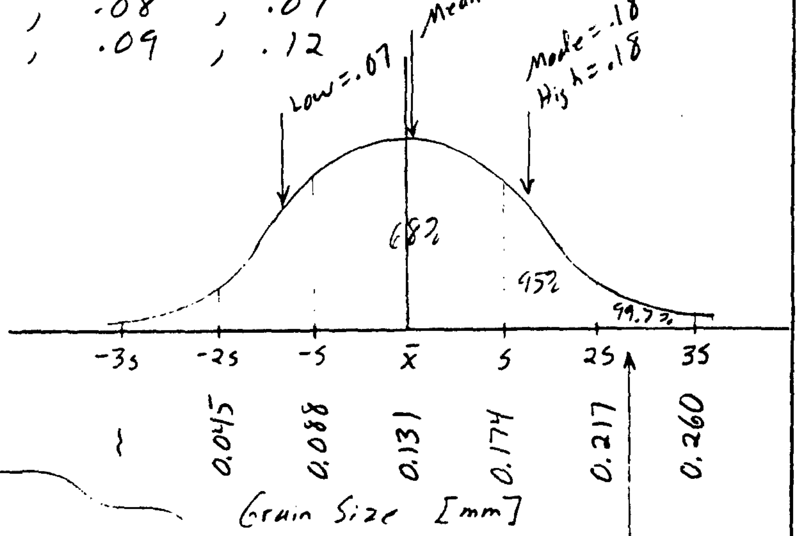
89-254 M	.14	.18	.16	.12
89-255 M	.18	.17	.11	
89-249 M	.18	.08	.07	
89-276 M	.07	.09	.12	
89-275 M	.17			

Student - t Distribution;

$n = 14$

$\bar{x} = .131$

$s = .043$



99% Confidence Limit $= \bar{x} + 2.33s$

$= 0.231$ mm

Permeability

	Hazen ①	WES ②
ave = .13 mm	.017 cm/s	.05 cm/s
99% C.L. = .23 mm	.053 cm/s	.15 cm/s
ave = .13 mm	.034 FPM	.10 FPM
99% C.L. = .23 mm	.104 FPM	.30 FPM

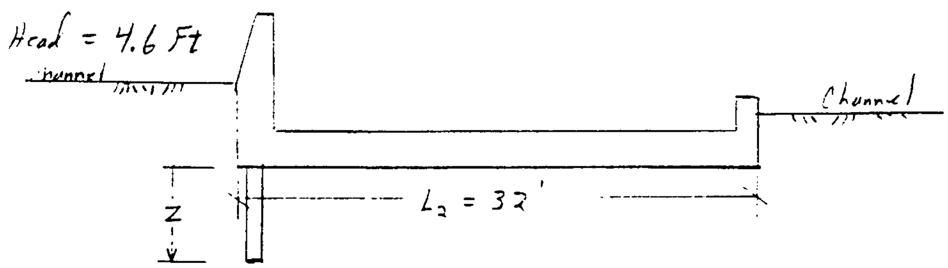
$K_h \approx .3$ FPM, max

① Holtz & Kovacs, Intro. to Geotechnical Engineering

② WES TM 3-424, fig. A-3b(2)

WES FORM NO. 1253
REV OCT 1968

SUBJECT:	COMPUTED BY: JAE	DATE: 2/3/92	FILE NO. ROCH DM6
Upstream Drop Structure	CHECKED BY:	DATE:	SHEET NO. 2



Blighs Creep Ratio, Ref. TM 3-424 p. 61

$$C = L_2/H = 32/4.6 \cong 7$$

For Fine Sand, Blighs Creep Ratio should be Greater Than 15. → No. Good.

Lanes Creep Ratio,

$$C_w = \frac{L_2/3 + \Sigma P}{H}$$

, ΣP = vertical Paths
ΣP = vertical From Channel Invert to Bottom of Cutoff
$\Sigma P = (993.2 - 988.7) + (991 - 988.7) + 2Z$
$\Sigma P = 6.8' + 2Z$

For No Cutoff:

$$C_w = \frac{32/3 + 6.8}{4.6} = 3.8$$

For Fine Sand, Lanes Creep Ratio should be Greater than 7.
No Good. Add Cutoff.

$$C_w = \frac{32/3 + 6.8 + 2Z}{4.6} = 7$$

$Z > 7.4'$ → Choose Cutoff to Elev. 980.0'

Head

U/s Water Level	1002.2	1002.9	1004.9	1006.3	998.2
Tail water	998.4	999.5	1001.6	1003.1	991.4
Head	3.8	3.4	3.3	3.2	6.8
Event	5yr	10yr	50yr	Design	N/A

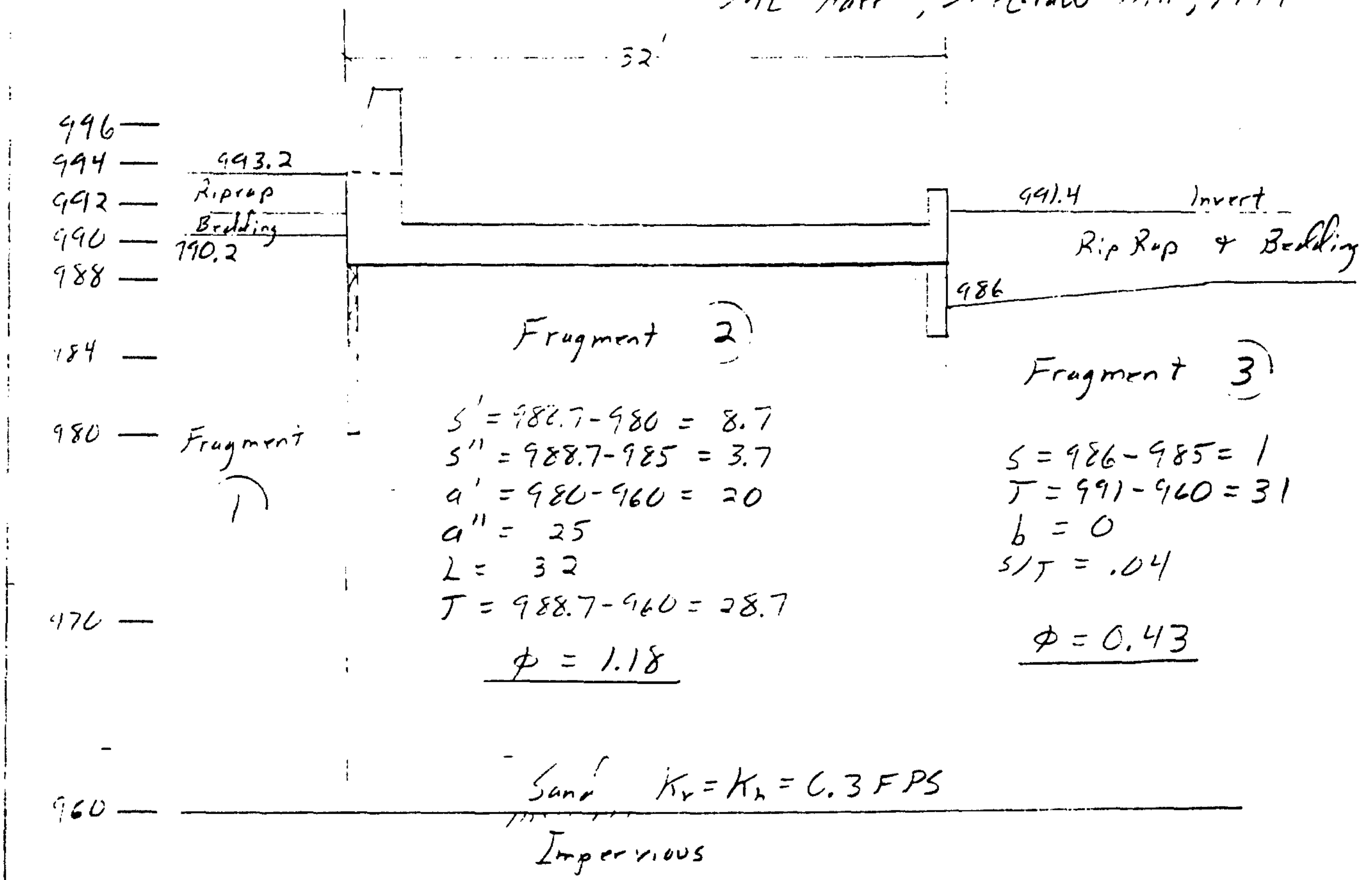
Use 3.8'.

Calculations completed for 4.6' based on preliminary water levels. → O.K.

SUBJECT: Upstream Drop Structure	COMPUTED BY: DAC	DATE: 2/3/92	FILE NO. ROCH DMG
	CHECKED BY:	DATE:	SHEET NO. 3

Seepage & Uplift head

Method of Fragments, Ref. Mechanics of Particulate Media, ME Harr, McGraw-Hill, 1977



Fragment 2

$S' = 988.7 - 980 = 8.7$
$S'' = 988.7 - 985 = 3.7$
$a' = 980 - 960 = 20$
$a'' = 25$
$L = 32$
$T = 988.7 - 960 = 28.7$

$\underline{\Phi = 1.18}$

Fragment 3

$S = 986 - 985 = 1$
$T = 991 - 960 = 31$
$b = 0$
$S/T = .04$

$\underline{\Phi = 0.43}$

1) $S = 990.2 - 981 = 9.2$
$T = 990.2 - 960 = 30.2$
$b = 0$
$S/T = .305$
$m = .461$

$\underline{\Phi = 0.73}$

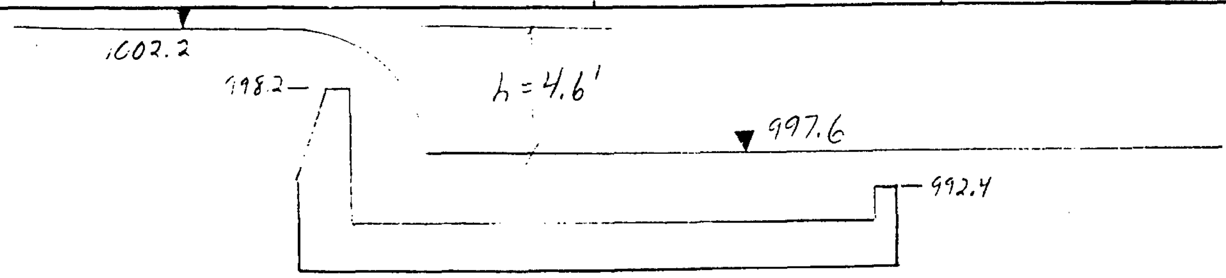
Seepage,

$$\$ = \frac{1}{\Sigma \Phi} = \frac{1}{2.34}$$

$$\underline{\$ = 0.43}$$

WES FORM NO. 1253
REV OCT 1968

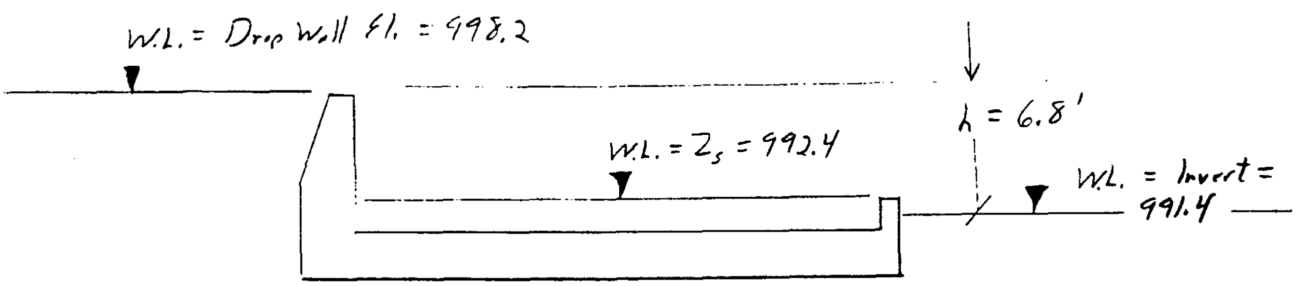
SUBJECT: Upstream Drop Structure	COMPUTED BY: DAC	DATE: 2/3/92	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 4



Case A - Normal Operation - 5 yr Event

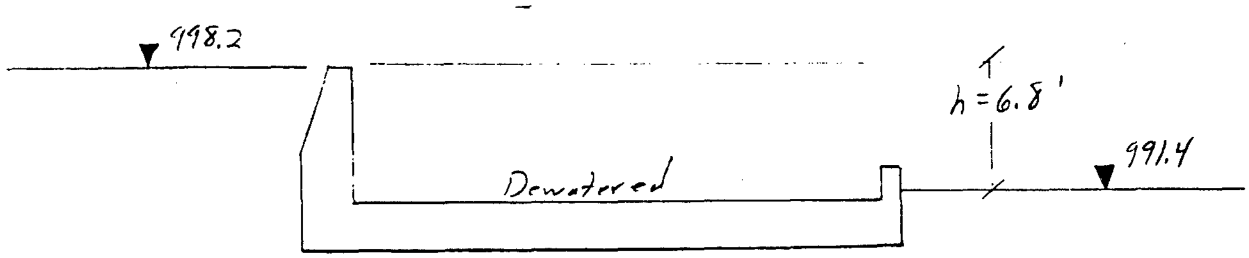
Required FS = 1.5 (Ref. ETL 1110-2-307)

Note: For Typical Daily Flows, water will pass thru Notch in Drop wall and heads will be less than 4.6'



Case B - Unusual Operation - Low Flow with Stop Logs to Form Upper Pool - No Flow thru notch in Drop Wall

Required FS = 1.3

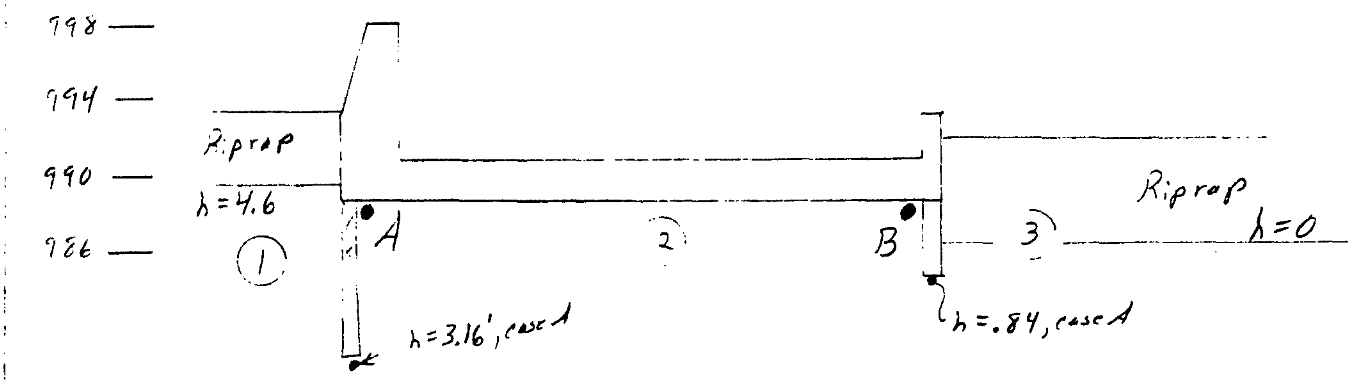


Case C - Extreme Maintenance / Construction

Required FS = 1.1

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Upstream Drop Structure	COMPUTED BY: DAC	DATE: 2/3/92	FILE NO. ROCH DM 6
	CHECKED BY:	DATE:	SHEET NO. 5



Case A, Head Loss in Fragments (h_L),

$$\boxed{h_L = \Delta h \left(\frac{\phi_i}{\Sigma \phi}\right)}$$

$$h_L^{(1)} = 4.6'\,(73/234) = 1.44'$$

$$h_L^{(2)} = 4.6'\,(118/234) = 2.32'$$

$$h_L^{(3)} = 4.6'\,(43/234) = \underline{0.84'}$$

$$4.6'$$

Head at Points A + B (Assume Line of Creep From Tip of Cutoffs)

$$h^{(A)} = 4.6' - 1.44 - 2.32\left(\frac{8.7}{8.7+32+3.7}\right) = \underline{2.71'}$$

$$h^{(B)} = 0.84 + 2.32\left(\frac{3.7}{8.7+32+3.7}\right) = \underline{1.03'}$$

Cases B + C

$$h_L^{(1)} = 6.8'\,(73/234) = 2.12'$$

$$h_L^{(2)} = 6.8'\,(118/234) = 3.43'$$

$$h_L^{(3)} = 6.8\,(43/234) = \underline{1.25'}$$

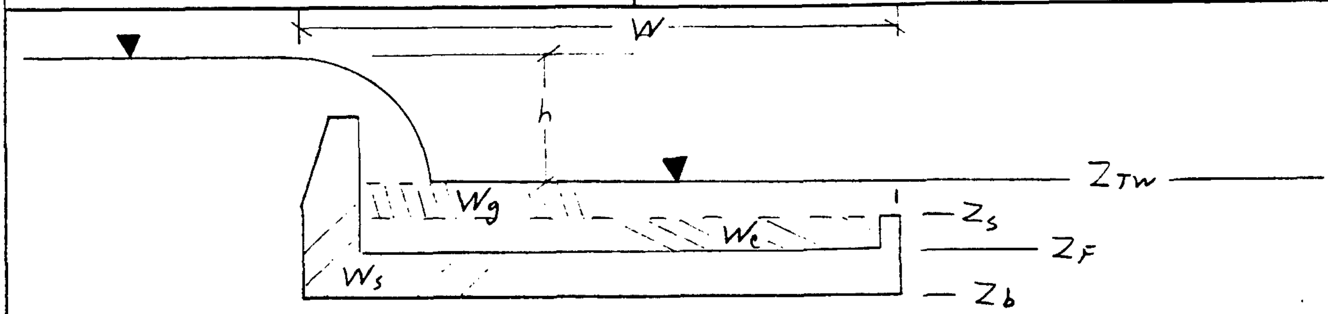
$$6.8'$$

$$h^{(A)} = 6.8 - 2.12 - 3.43\left(\frac{8.7}{8.7+32+3.7}\right) = \underline{4.01'}$$

$$h^{(B)} = 1.25 + 3.43\left(\frac{3.7}{8.7+32+3.7}\right) = \underline{1.54'}$$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Upstream Drop Structure	COMPUTED BY: DAC	DATE: 2/3/92	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 6



Notation

Z_{TW} - El. Tailwater

Z_s — Sill El. $= 992.4$

Z_F — Floor El. $= 990.7$

Z_b — Base El. $= 988.7$

$\gamma_{H_2O} = 62.4$ pcf

L - Length $= 140'$

W - Width $= 32'$

H - Height

h - head

$\gamma_t = 150$ pcf For Concrete

$$W_s = \left[(\text{Vol.})_{slab} + (\text{Vol.})_{Drop\,wall} + (\text{Vol.})_{SILL\,WALL} + (\text{Vol.})_{SIDE\,WALLS}\right]\gamma_t$$

$$W_c = LW(Z_s - Z_F)\gamma_{H_2O} \qquad (\text{For } Z_{TW} \geq Z_s)$$

$$W_g = LW(Z_{TW} - Z_s)\gamma_{H_2O}$$

$$U = LW\left[(h^{A} + h^{B})/2 + (Z_{TW} - Z_b)\right]\gamma_{H_2O}$$

$$FS = \frac{W_s + W_c}{U - W_g}$$

Weight of Structure, W_s

	L	W	H	(Vol.)
Slab	140	32	2	8960
Drop Wall	140	3	2.5	1050
Drop Wall	140	(1.5 + 3)/2	5	1575
Sill Wall	140	1	1.7	238
Side Walls	2 * 32	1.5	13.8	1325

13,150 Ft^3 = 487 yd^3

For $\gamma_t = 150$ pcf, $\underline{\underline{W_s = 1972^K}}$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Upstream Drop Structure	COMPUTED BY: DAC	DATE: 2/3/92	FILE NO. ROCH DM 6
	CHECKED BY:	DATE:	SHEET NO. 7

Uplift Factors of Safety,

Ref. Flotation Stability Criteria for Concrete Hydraulic Structures, ETL 1110-2-307, 8/20/87

$$FS = \frac{W_s + W_c}{U - W_g}$$

S = Surcharge Loads = 0
→ Ignore Cutoffs

Case A, $W_s = 1972^k$

$W_c = L \cdot W \cdot H \cdot \gamma = 140(32)(992.4 - 990.7)\,62.4 = 475^k$

$U = 140(32)\left[\left(\frac{2.71 + 1.03}{2}\right) + (997.6 - 988.7)\right]62.4 = 3011^k$

$W_g = 140(32)(997.6 - 992.4)\,62.4 = 1454^k$

$FS = (1972 + 475)/(3011 - 1454) = 1.57 \quad (> 1.5)$ OK

Case B, $W_s = 1972^k$, $W_c = 475^k$, $W_g = 0$

$U = 140(32)\left[\left(\frac{4.01 + 1.54}{2}\right) + (991.4 - 988.7)\right]62.4 = 1531$

$FS = (1972 + 475)/(1531 - 0) = 1.60 \quad (> 1.3)$ OK

Case C, $W_s = 1972^k$, $W_c = 0$, $W_g = 0$

$U = 1531^k$

$$FS = \frac{1972 + 0}{1531 - 0} = 1.29 \quad (> 1.1) \text{ OK}$$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Upstream Drop Structure	COMPUTED BY: DAC CHECKED BY:	DATE: 1/27/92 DATE:	FILE NO. ROCH DM6 SHEET NO. 8

Check Seepage

w/o Cutoff, $\$ = \frac{d}{L_2 + .86d} = \frac{28.7}{32 + .86(28.7)} = .506$

with Cutoff, $\$ = 0.43$ (From Fragments)

$Q = \$K\phi = .43(0.3\ FPM)(4.6') = 0.59\ CFM/LF$
$= 59\ CFM / 100\ LF$
$= 440\ GPM / 100\ LF$

Medium to Heavy Seepage, but mostly due to large area of flow. Seepage will not surface downstream, except within the channel.

Piping Potential at Toe

Critical Gradient,

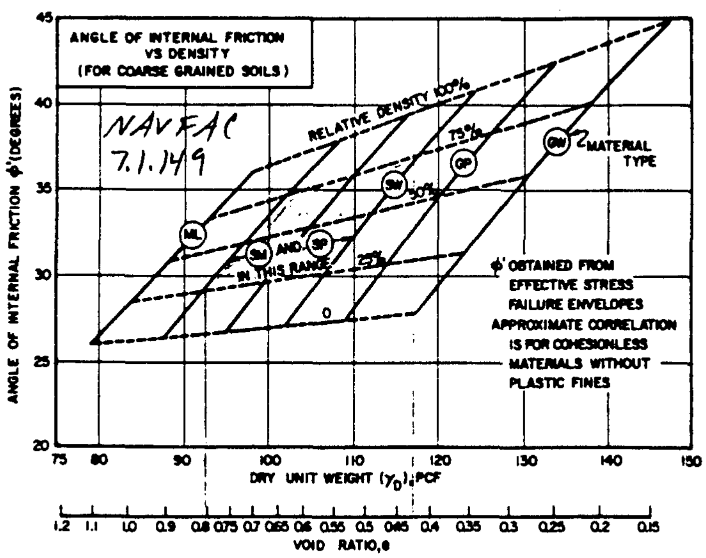
$i_c = \frac{G-1}{1+e} = \frac{2.8-1}{1+e}$

upper range of e From Fig. is about 0.8,

$\underline{i_c = 1.0}$

Ref. TM 3-424,

For Fine Sand, use $\underline{i_c = .85}$



$i_{ave} = \frac{\$h}{A} = .43(4.6')/28.7' = 0.07$

$FS = \frac{i_{cr}}{i} = \frac{.85}{.07} = 12$

Factor of Safety of 6 - 7 recommended For Fine Sand. (Ref. Harr, Mech. of Particulate Media, p.178). This should be OK based on i_{ave}. Downstream seepage cutoff will limit Flow net concentration at toe.

WES FORM NO. 1253
REV OCT 1968

APPENDIX C

GEOTECHNICAL DESIGN

COMPUTATIONS FOR DOWNSTREAM DROP STRUCTURE

SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: DAC	DATE: 12/11/91	FILE NO. ROCH DM 6
	CHECKED BY:	DATE:	SHEET NO. 1

Uplift Analysis

Down stream drop structure is founded on rock. The sedimentary rock is known to be stratified, with some layers being significantly more porous & uncemented than the majority of the rock. The worst case for uplift would be if an uncemented layer ran continuous beneath the foundation at a relatively shallow depth and was interconnected to the granular Drainage Blanket by fractures.

Since the stratification of porous layers in the rock is unknown, the seepage path of flow entering the drainage blanket can not be determined. Thus, assume LINE OF CREEP method to determine uplift pressures. [Ref. EM 2502, §3.19]

Line of Creep is equivalent to assuming constant thickness of flow path,

$$q = k\frac{\partial \phi}{\partial x}, \quad Q = qA, \quad A = Lt$$

t = constant

$$\underline{Q = kL\frac{\partial \phi}{\partial x}}$$

Drop Wall (see next p.)

Seepage Path = 1.5' + .5' + 2' + 1' + 1' = 7 Ft

$$Q = kL\frac{\partial \phi}{\partial x}$$

$$Q = k_R(35')\left(\frac{H_R}{7'}\right)$$

$$\underline{Q_{in} = 5K_R H_R}$$

Side Wall

Same as drop wall

$$\underline{Q_{in} = 5K_R H_R}$$

Drainage Blanket (see next page)

$L = 35'$, $\partial x = 35'$

$$Q = K_s(35')H_s/35'$$

$$\underline{Q_{out} = K_s H_s}$$

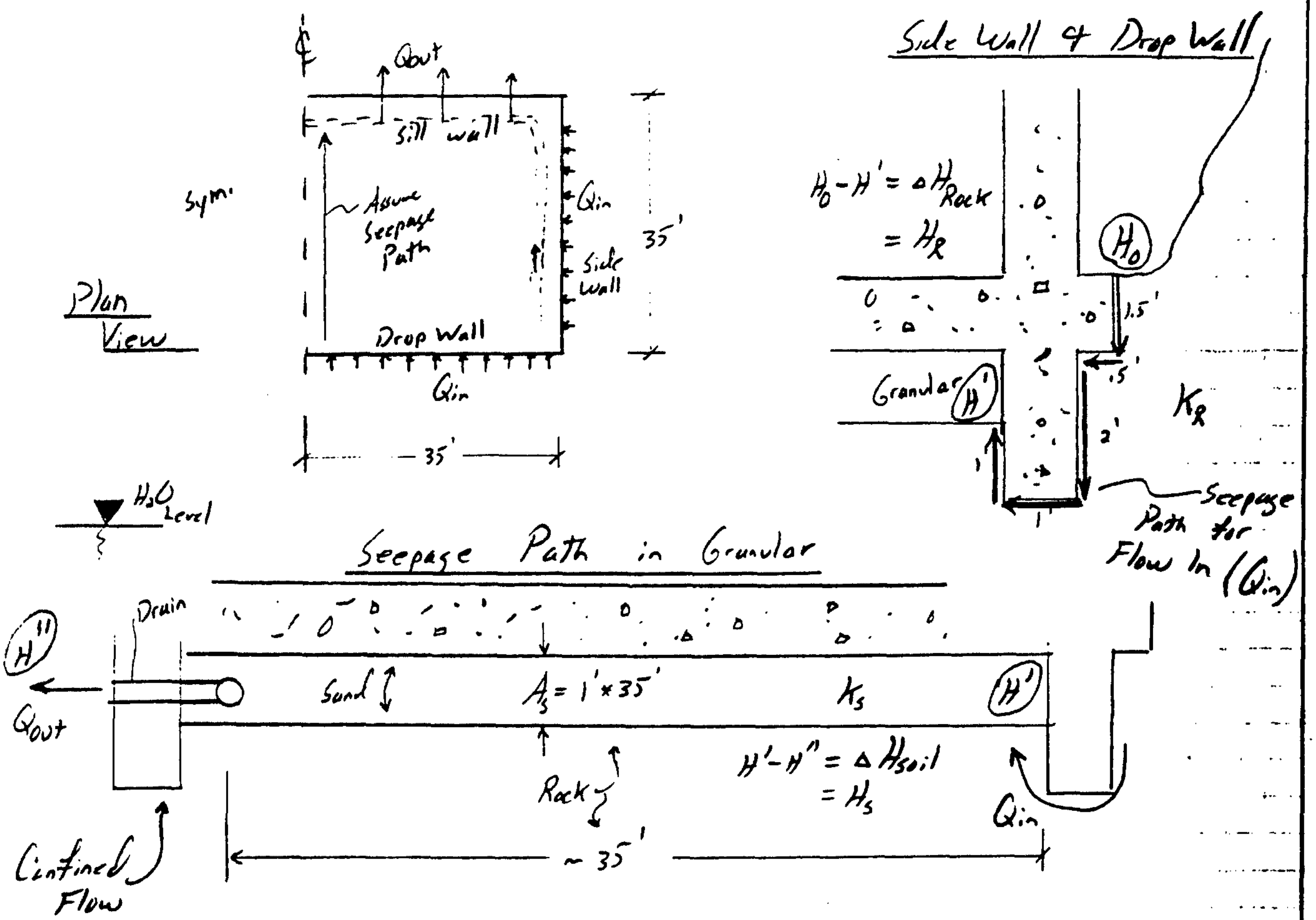
In Flow = Out Flow

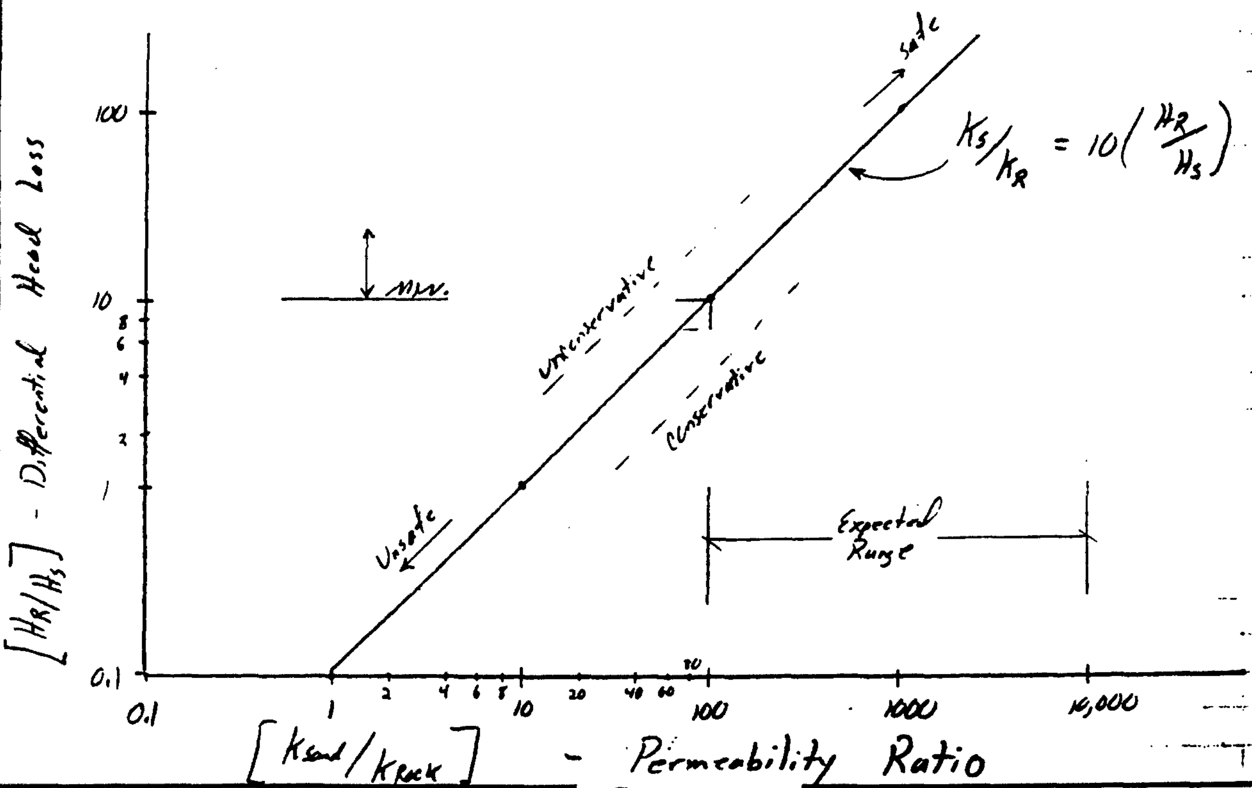
$$5K_R H_R + 5K_R H_R = K_s H_s$$

$$\boxed{\left(\frac{K_s}{K_R}\right) = 10\left(\frac{H_R}{H_s}\right)}$$

$$\frac{\text{Soil Permeability}}{\text{Rock Permeability}} = 10\left(\frac{\text{Head Loss in Rock}}{\text{Head Loss in Soil}}\right)$$

SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: DAC	DATE: 12/11/91	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 2





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REV OCT 1968

SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: RAC	DATE: 12/11/91	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 3

Permeability Ratio,

Grain Size of Sandstone is similiar to overburden fine sands with a $D_{10} \simeq 0.2$ mm. Assume upper bound permeability for sandstone with uncemented layer,

$$K_{Rock} = 0.1 \text{ cm/sec} \quad \text{for uncemented}$$

Typical Values for permeability of Sandstone in textbooks range from $\sim 10^{-5}$ cm/s or lower to 10^{-3} cm/sec for Navajo Sandstone, with porosity $\approx 15\%$.

Drainage Fill Specification < 1% Passing #10 sieve (2mm). Assume $D_{50} \simeq 3.3$ mm (conservative for MnDOT CA-50 coarse concrete aggregate). From Hazens Eqn.,

$$K_s \simeq 10 \text{ cm/sec.} \quad \text{for Drainage Blanket.}$$

Probable Permeability Ratio:

$$\frac{10}{.1} < \left(\frac{K_s}{K_R}\right) < \frac{10}{10^{-3}}$$

$$100 < \frac{K_s}{K_R} < 10{,}000$$

From Graph on p. 2, $H_R/H_s \geq 10$

For Head Loss of 3.8', Head Loss in Sand would be about 0.35 Ft & Head Loss in Rock would be about 3.45 Ft.

Conservative Assumptions: ① Conservative Flow Path in Drainage Blanket, Longest possible.

② Total Upstream Head assumed along Length of Side wall

③ Rock Permeability

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: DAC	DATE: 12/11/91	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 4

Unconservative Assumptions:

① Clogged Drains could increase D/S Head – not likely due to Rock Foundation & Course Drainage Fill Material

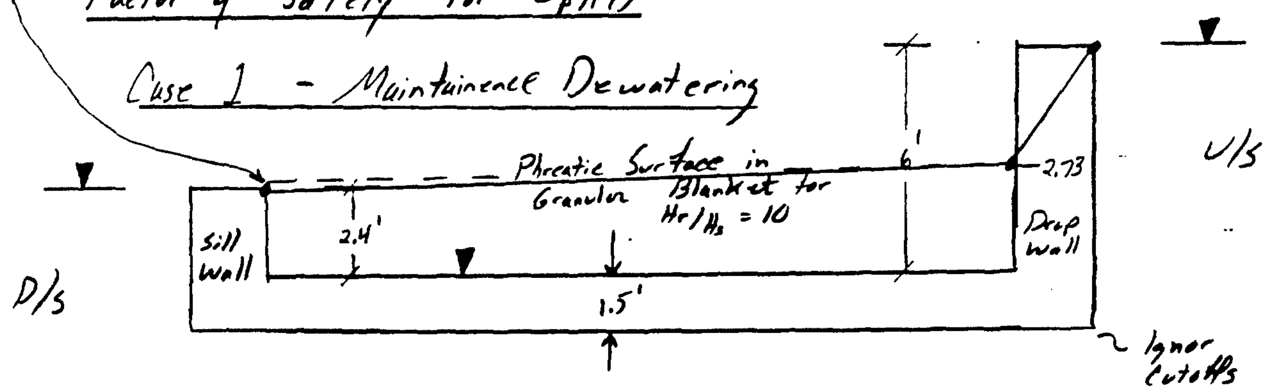
② Leaks thru joints or No waterstop could increase flow into Drainage Blanket

③ Line of Creep Assumption – Rock Jointing could alter flow path around/under cutoff walls

For Drains 50% Effective, Tailwater = 2.56'

Factor of Safety for Uplift

Case 1 – Maintainence Dewatering



Max. Tailwater → Use FS for extreme Conditions

$$\Delta H = 6' - 2.4' = 3.6'$$

$$2.4 + \frac{3.6}{11} = 2.73'$$

Assume Saturated Unit Weight of Concrete = 150.0 pcf

		W	L	H		
Weight of Structure:	Sill wall =	(1.0)	(75)	(2.4)	150 =	27.0 K
	Drop wall =	(1.5)	(75)	(6.0)	150 =	101.3
	Slab =	(39)	(79)	(1.5)	150 =	693.2
	Side Wall =	(1.0)	(2*35)	(19)	150 =	199.5
						1021.0

WES FORM NO. 1253 REV OCT 1968

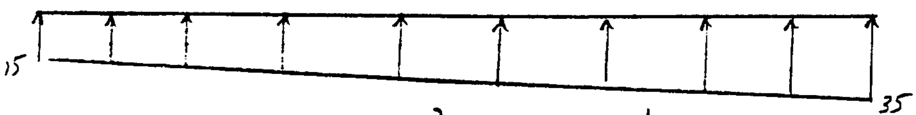
SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: DAC	DATE: 12/11/91	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 5

Uplift Force:

$$\text{Sill wall} = (2')(79)(2.4+1.5)\,62.4 = 38.5^{K}$$
$$\text{Slab} = (35')(79')\left(\frac{2.56+2.73}{2}+1.5\right)62.4 = 715.2$$
$$\text{Drop wall} = (2')(79')\left(\frac{2.73+6}{2}+1.5\right)62.4 = 57.8$$
$$811.5$$

$$FS = \frac{1021.0}{811.5} = 1.26 > 1.1 \quad \underline{\text{ok}}$$

Excess Uplift Force on Slab (unbalanced by concrete slab weight) $= 2.4(62.4) - 1.5(90) = 15\ psf$ D/S
$2.73(62.4) - 1.5(90) = 35\ psf$ U/S



$$M \cong 25_{psf}(35')^2/8 = 3.8^{\pm}\ \text{Kip-Ft}$$

→ Small

$$I = \frac{bd^3}{12} = \frac{12'(18)^3}{12} = 5832\ in^4/Ft$$

→ Structural Dept.

$c = 9''$

$$\nu = \frac{Mc}{I} = \frac{(3860\ Ft\text{-}lbs)(12''/Ft)(9'')}{5832\ in^4} = 70\ psi$$

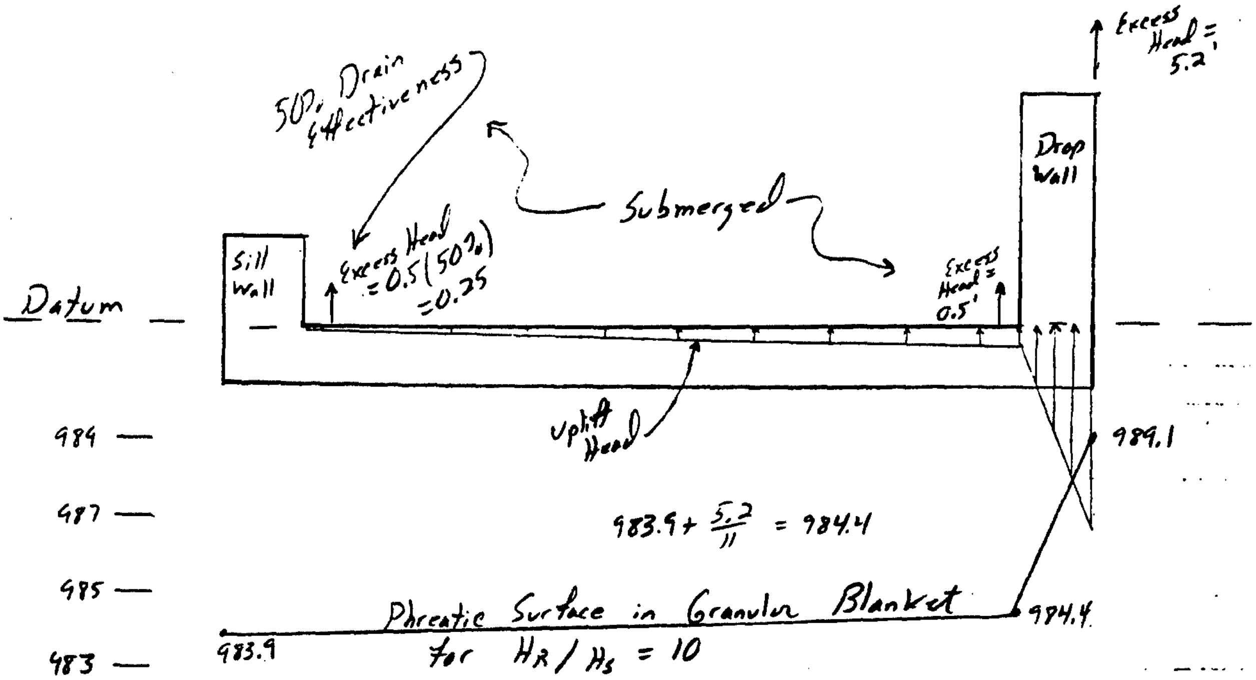
Case 2 - Operations

	Water Surface Profiles 5yr	10yr	25yr	50yr	100yr	Design	SPF
Sta. 12+40 (D/S)	979.7	980.5	982.0	982.9	983.9	984.8	994.9
Sta. 13+30 (U/S)	983.9	984.9	986.6	987.9	989.1	990.1	996.2
Head Differential	4.1	4.4	4.6	5.0	5.2	4.9	1.3

Most Critical

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: DAC	DATE: 12/11/91	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 6



At Edge of Drop Wall (For Slab Only):

$$\text{Uplift} = (0.5' + 1.5)\, 62.4 = 124.8 \text{ psf}$$

$$\text{Slab Weight} = (1.5')\, 150 = 225 \text{ psf}$$

$$FS = \frac{225}{124.8} = 1.8 > 1.5 \checkmark$$

OK

Approx. & Conservative

Bear Creek
D/S Drop Structure

DAC 12/12/91 7

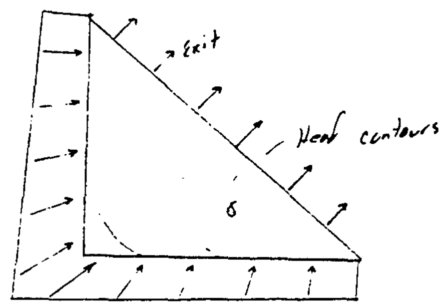
Line of Creep

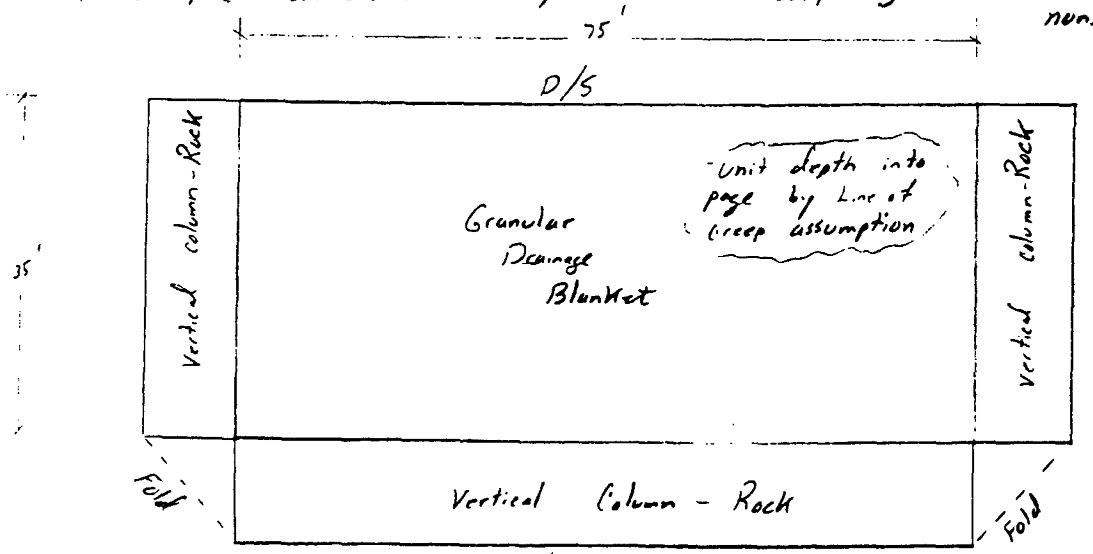
"Proportional to"

Reduces $Q = kA\frac{\partial\phi}{\partial t}$ to $Q \propto kL\frac{\partial\phi}{\partial t}$

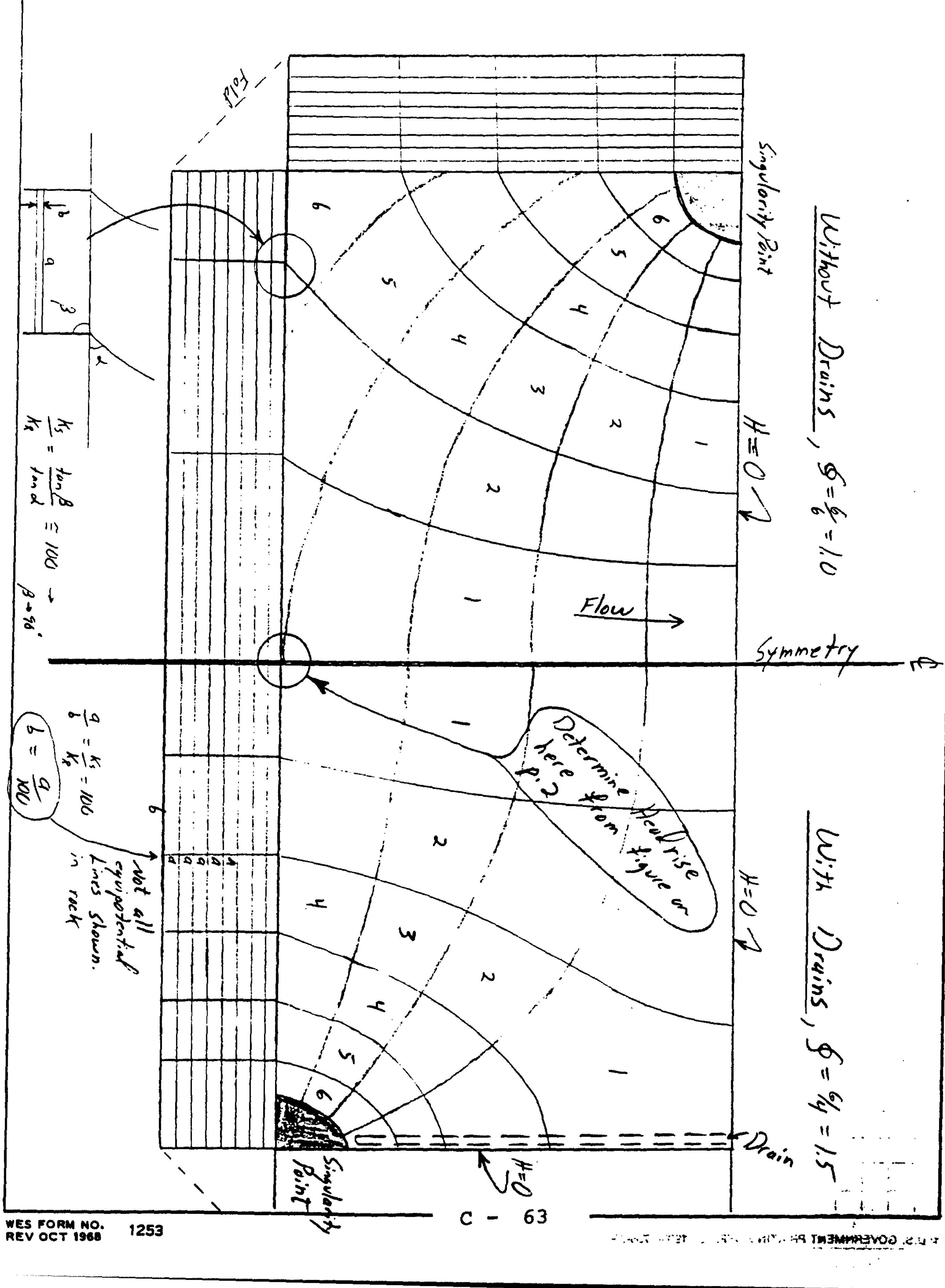
where $A = Lt$, t = Constant.

This reduces 2D problem (which would involve a flow net or some other method to determine the shape factor $ to a 1D problem. A 3D problem, such as at the corner of a Lock/Drop Structure, etc. can be reduced to a 2D problem as indicated. Then construct flow net for 2D simplification. SEEPS will not accept boundary conditions for horizontal flow problem and will adjust BC's to solve a nonsense problem.





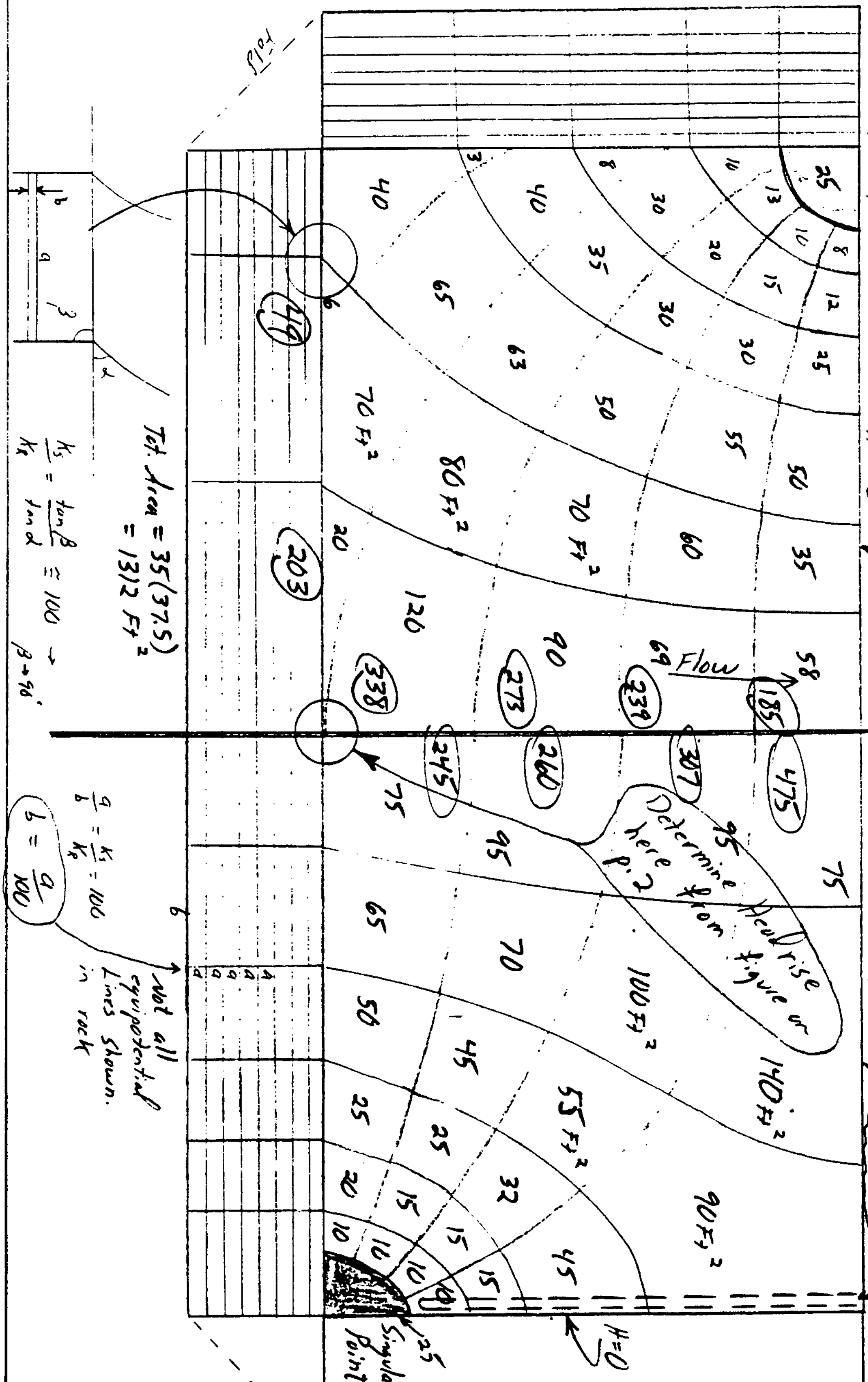
SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: DAC	DATE: 12/12/91	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 8



WES FORM NO. 1253
REV OCT 1968

SUBJECT: Bear Creek D/S Drop Structure	COMPUTED BY: DAC	DATE: 12/12/91	FILE NO. 9
	CHECKED BY:	DATE:	SHEET NO.

Net Ave. Head on Slab (w.r.t. U/S Head at ℄)



$$\text{Ave Head} = \tfrac{1}{8}(185) + \tfrac{3}{8}(239) + \tfrac{5}{8}(273) + \tfrac{7}{8}(338) + \tfrac{9}{8}(203) + 1.3(49)$$

$$= \frac{231 + 89.6 + 170.6 + 295.8 + 228.4 + 63.7}{1312 - 25}$$

$$= 68\%$$

Without Drains, $\Phi = 6/6 = 1.0$

$$\text{Ave. Head} = \tfrac{1}{8}(475) + \tfrac{3}{8}(307) + \tfrac{5}{8}(260) + \tfrac{7}{8}(245)$$

$$= \frac{59.4 + 115.1 + 162.5 + 214.4}{1312 - 25}$$

$$= 43\%$$

With Drains, $\Phi = 6/4 = 1.5$

Note: For ∞ Cross Section, 2D case would be 50%

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Bear Creek D/s Drop Structure	COMPUTED BY: DHC	DATE: 12/16/91	FILE NO. ROCH-DM6
	CHECKED BY:	DATE:	SHEET NO. 10

Case 2A - Operation & Cutoff Failure

Note; Drain Effectiveness not included in previous cases since influence is very small. For Case 2A, drain effectiveness is significant.
Ref: EM 2200 (9/25/58) p. 4
ETL 256 (6/24/81) pp. 17-18
Effectiveness of drains ranges from 25-50%. For D/S dropstructure, the drains will be embedded in the coarse drainage aggregate laid on rock without contact with soil. The interaction of the perforated pipe with the coarse aggregate is very good and the potential for clogging is non existent. Possible causes of drain ineffectiveness include crushed pipes and rip rap plugging the outlets. Choose Effectiveness = 50%.

(From p. 9, Drained Condition)

$$\text{Ave. Net Head on Base} = 50\%(5.2') + 43\%(50\%)5.2'$$
$$= 2.6' + (.43)\,2.6'$$
$$= \underline{3.72'}$$

$$\text{Uplift},\ (U - W_g) = 3.72'/39')(79')\,62.4 = 715.2^{k}$$

$$\text{Water in Structure},\ W_e = (974.2 - 971.8)(35')(75')\,62.4 = 393^{k}$$

$$\text{Structure},\ W_s = 1021^{k} \quad (\text{from p. 4})$$

$$FS = \frac{W_s + W_e + S}{U - W_g}$$

$$FS = \frac{1021 + 393}{715.2}$$

$$FS = 1.98 > 1.5 \quad \underline{\underline{OK}}$$

APPENDIX C

GEOTECHNICAL DESIGN

COMPUTATIONS FOR LEVEE

SUBJECT: Levee	COMPUTED BY: DAC	DATE: 3/92	FILE NO. ROCH DMG
	CHECKED BY:	DATE:	SHEET NO. 1

Sand Permeability at Left Bank Levee

D_{10} Grain Size Tests at Nearby Borings [mm]

81-38M	.10	.13		
89-249M	.18	.08	.07	
89-250M	.17			
89-253M	.21			
89-254M	.14	.18	.16	.12
89-255M	.18	.17	.11	
89-257M	.05	.09		
89-258M	.14			
89-275M	.17			
89-276M	.07	.09	.12	

Student-t Distribution

$n = 21$

$\bar{x} = 0.130$

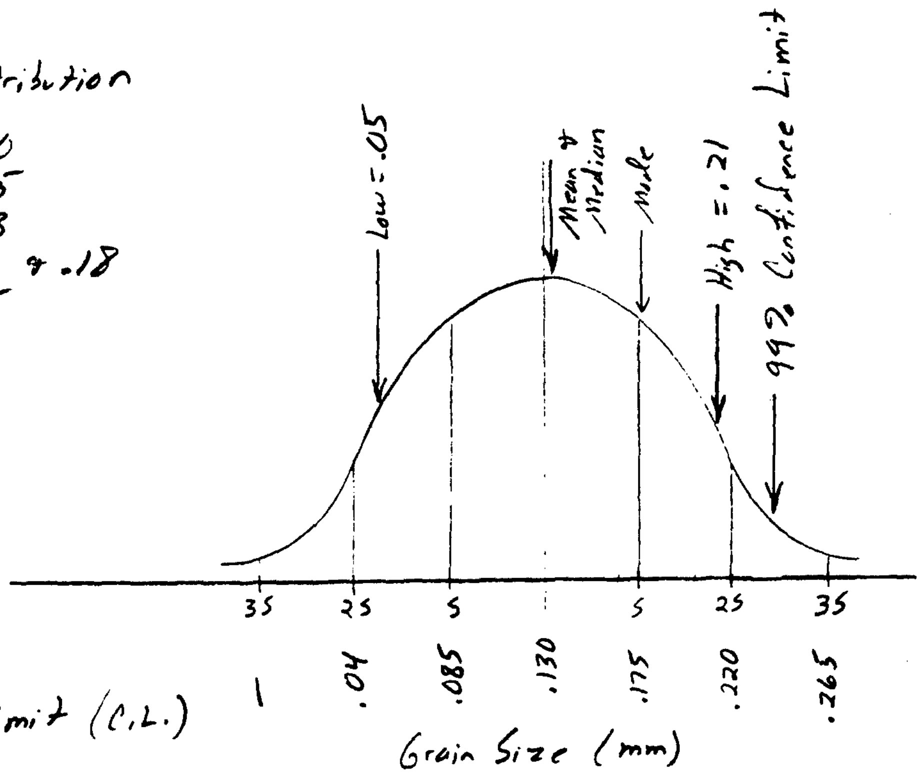
$s = 0.045$

Median = .13

Mode = .17 & .18

Low = .05

High = .21



99% Confidence Limit (C.L.)

$= \bar{x} + 2.33s$

$= .13 + 2.33(.04)$

$= \underline{\underline{0.235\text{ mm}}}$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Levee	COMPUTED BY: DAC	DATE: 3/92	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 2

Reference Permeability - Grain Size Correlations:

1) Hazen's Equation - $K_{(cm/s)} = C\,D_{10}^2\,[mm]$

- $0.4 < C < 1.2$, $C_{Typical} = 1.0$
- For $K < 10^{-3}$ cm/s
- Good Correlation to Permeability of Remolded Lab samples or Fill Soils.

2) WES Method

- Waterways Experiment Station Correlation for Middle & Lower Mississippi River Valley
- Ref: EM 1901, p. 2.29
  EM 1913, p. 3.13
  WES TM No. 3-424
- Good Correlation to in-situ alluvial deposits, For K_H

3) Masch & Denny Relationship

- Ref. EM 1901, p. 2.23

	Hazen	WES	Masch + Denny ③
Average	.017 cm/sec ①	.05 cm/sec ①	.013
Maximum	.053 cm/sec ②	.15 cm/sec ②	.025

① $D_{10} = .13$ mm
② $D_{10} = .23$ mm
③ Calculations Attached

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Permeability Estimate for Sand Near Levee	COMPUTED BY: DAC	DATE: 11/25/91	FILE NO. Bear Creek
	CHECKED BY:	DATE:	SHEET NO. 3

Gradation Curve	Size (mm)					φ Factor					σ_I
	D_5	D_{16}	D_{50}	D_{84}	D_{95}	D_5	D_{16}	D_{50}	D_{84}	D_{95}	
Fine Limit SP Sands	.07	.19	.35	.60	1.1	3.84	2.40	1.51	0.74	-.14	1.02
Coarse Limit SP Sands	.28	.41	.65	6.0	$ 23.	1.84	1.29	0.62	-2.59	-4.52	1.93
81-38M S-1	.05	.20	.33	.40	.70	4.32	2.32	1.60	1.32	0.51	0.83
81-38M S-3	.075	.20	.35	.65	1.8	3.74	2.32	1.51	0.62	-.85	1.12
81-38M S-8	.01*	.075	.70	1.8	6.0	6.64	3.74	0.51	-.85	-2.59	2.55
89-250M S-2	.12	.20	.28	.31	.50	3.06	2.32	1.84	1.69	1.00	0.47
89-250M S-4	.01*	.03*	.28	.45	.80	6.64	5.06	1.84	1.15	0.32	1.94

* Estimate $ - out of Limits

$$\sigma_I = \frac{D_{16} - D_{84}}{4} + \frac{D_5 - D_{95}}{6.6}$$

Typical 0.75 cm/min.

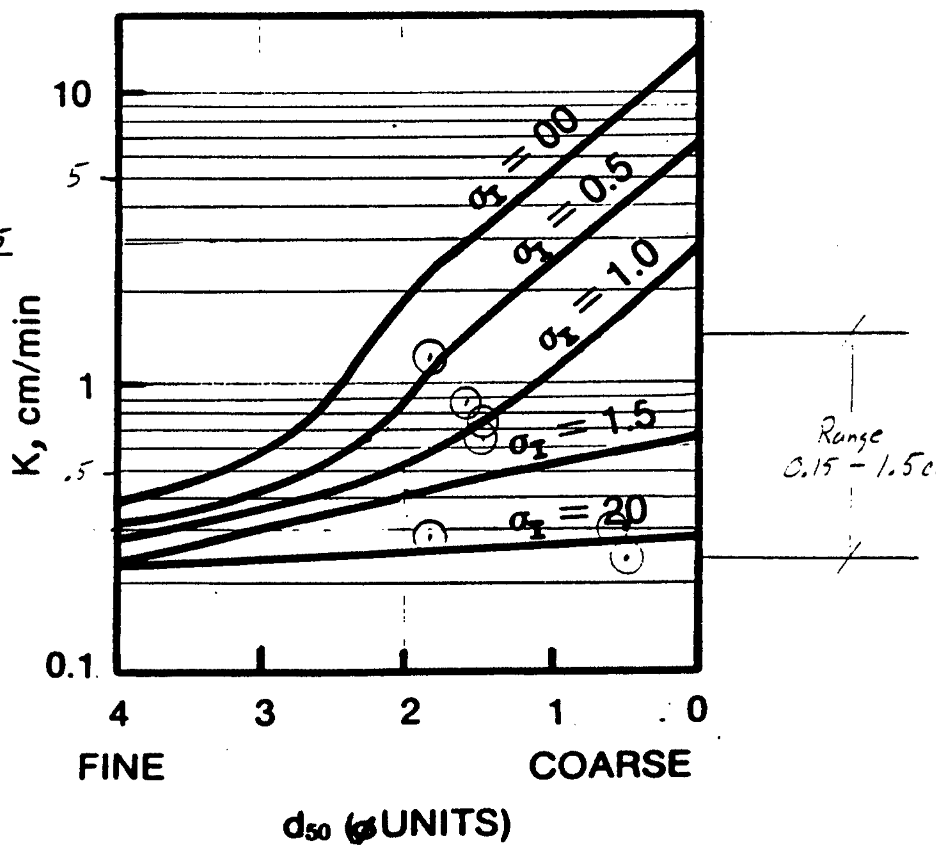
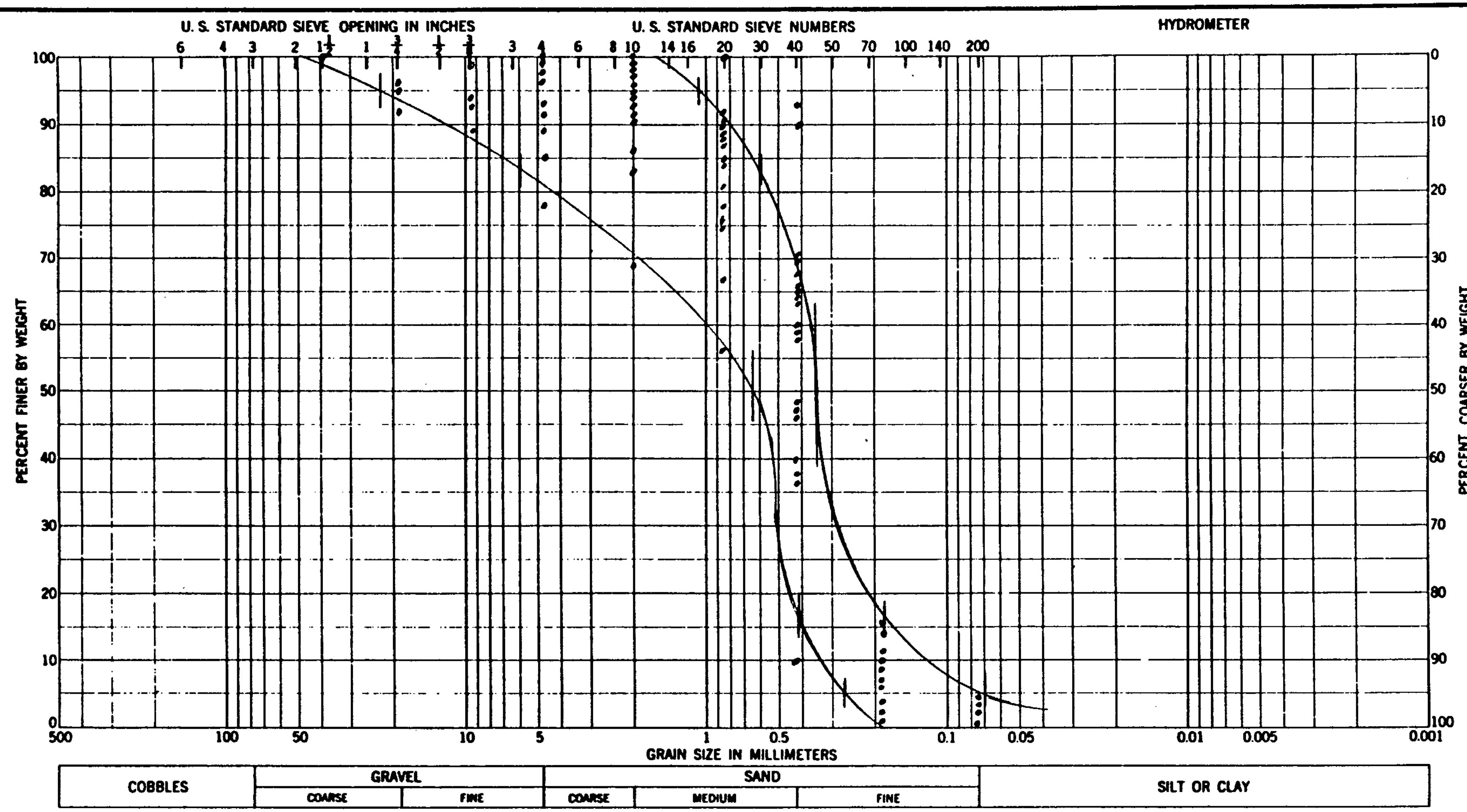


Figure 2-14. Masch and Denny relationship for permeability as a function of median grain size and inclusive standard deviation (courtesy of Prentice-Hall[175])

WES FORM NO. 1253
REV OCT 1968



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project Rochester Stage 4/ Bear Creek

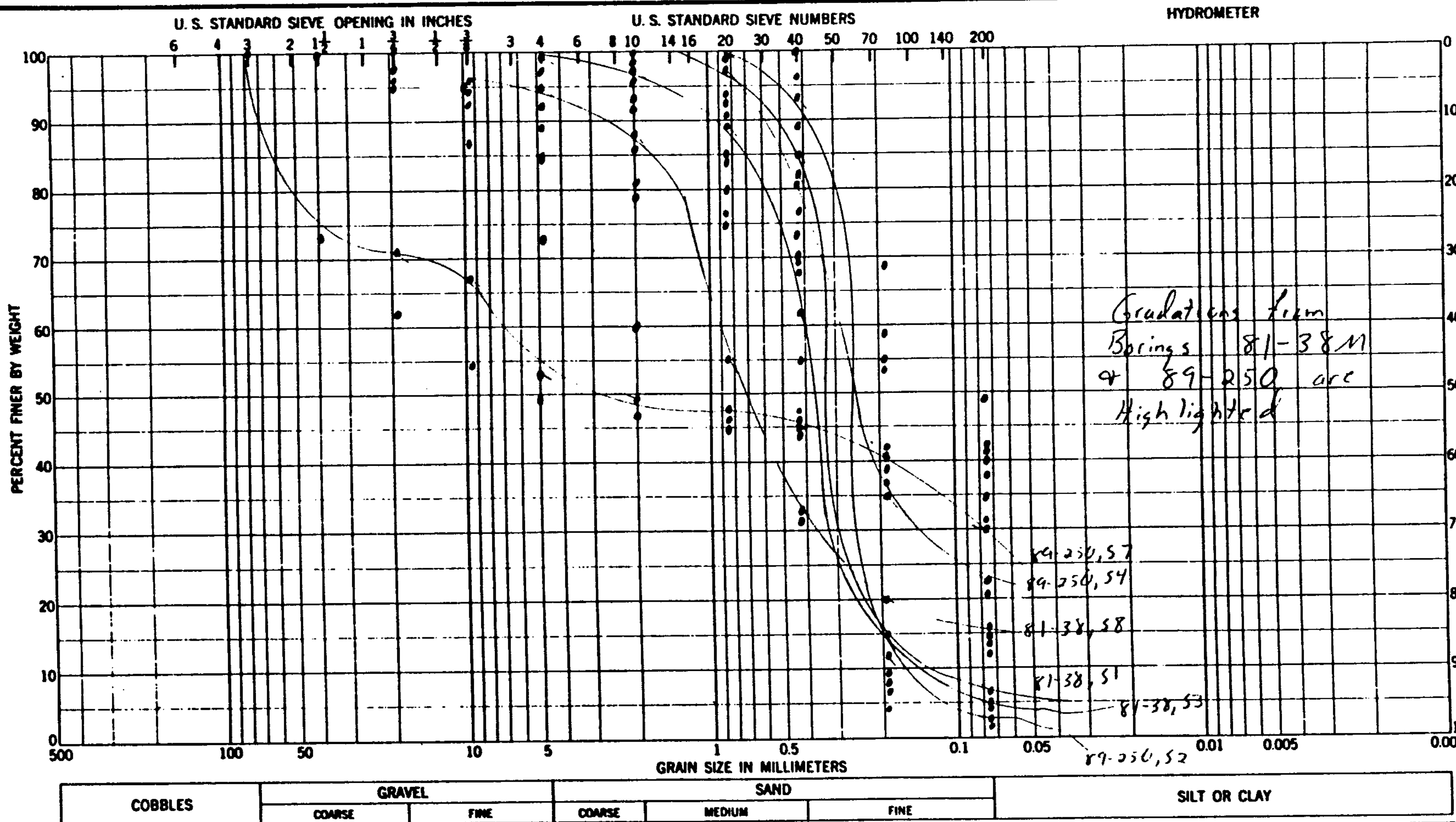
Area (SP) Sands on all

Boring No. Bear Creek Borings

Date 11/25/91

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification		Nat w %	LL	PL	PI
Included	Borings:	81-34M	81-37M				
		81-38M	81-40M				
		81-41M	89-250M				
		89-253M					

Project: Rochester Stage 4
Bear Creek
Area: Borings Near Levee
Boring No.
Date: 11/25/91

GRADATION CURVES

ENG FORM 1 MAY 63 2087

SUBJECT: Levee	COMPUTED BY: DK	DATE: 3/92	FILE NO. ROCH DM6
	CHECKED BY:	DATE:	SHEET NO. 6

Levee Seepage

Analysis Methods:

1) Flow Net
   - See Attached page
   - For No Ditch
2) Analytical / Method of Fragments
   - See Attached
   - For No Ditch
3) Finite Element Method
   - SEEPS code written by J. Kuppusamy Virginia Tech. 5/91
   - Include Ditch, Relief Trench in model
   - Investigate 6 cases at various stages of Headwater / Tailwater
   - Use water stages as attached on Figure

Allowable Criteria:

Reference EM 1913, p. C5

- Maximum Allowable Seepage Rate =
  $Q = 200$ GPM Per 100 LF
  $Q = 0.267$ CFM / LF
- Maximum Allowable Gradient at Toe (i) (upward) = 0.3

Design Criteria:

- Assume Typical Levee Section, 10 Ft Top width, 6 Ft High above average Landside Ground elevation, 5H:1V Landside slope, 3H:1V Riverside slope, 2 Ft Ditch with bench - See Attached pages
- Assume River Stages on Attached Figure

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Levee Seepage Flow Net

COMPUTED BY: DAC

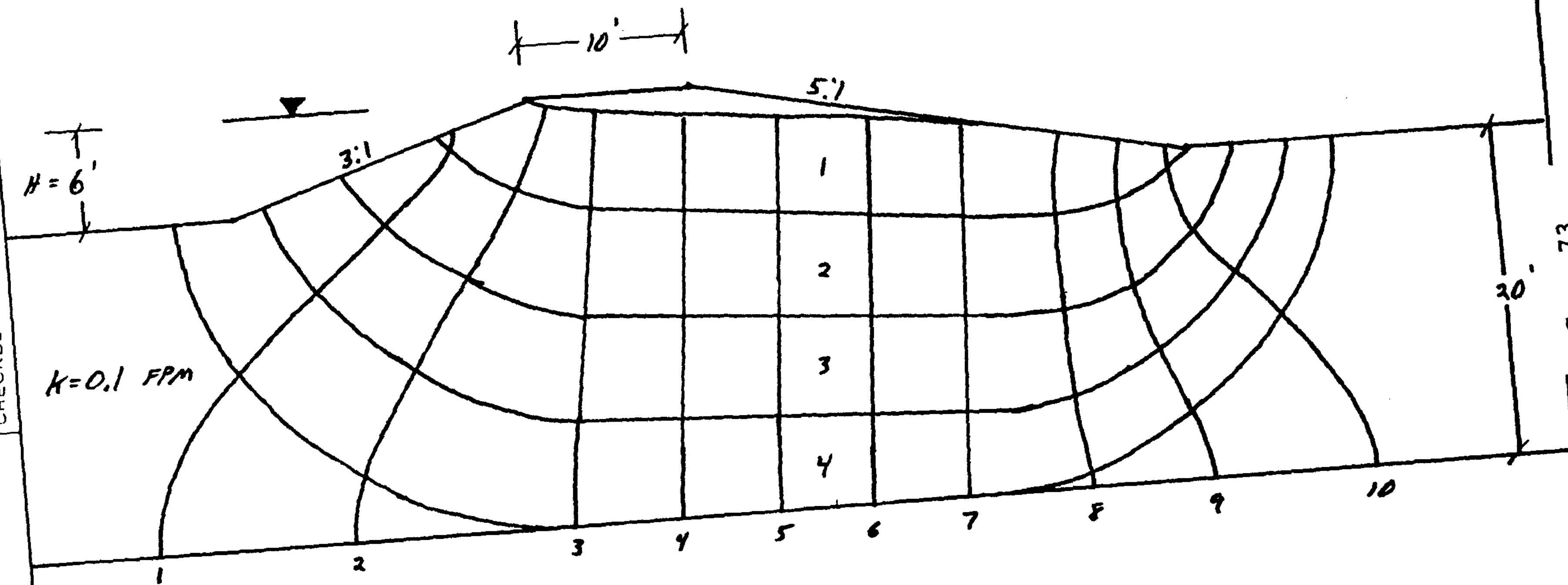
DATE: 11/21/91

FILE NO.

CHECKED BY:

DATE:

SHEET NO. 7



$i_{ave} = \frac{N_F H}{N_d d} = \frac{4(6')}{10(20')}$

$i_{ave} = 0.12 \quad < 0.3$ ✓ OK

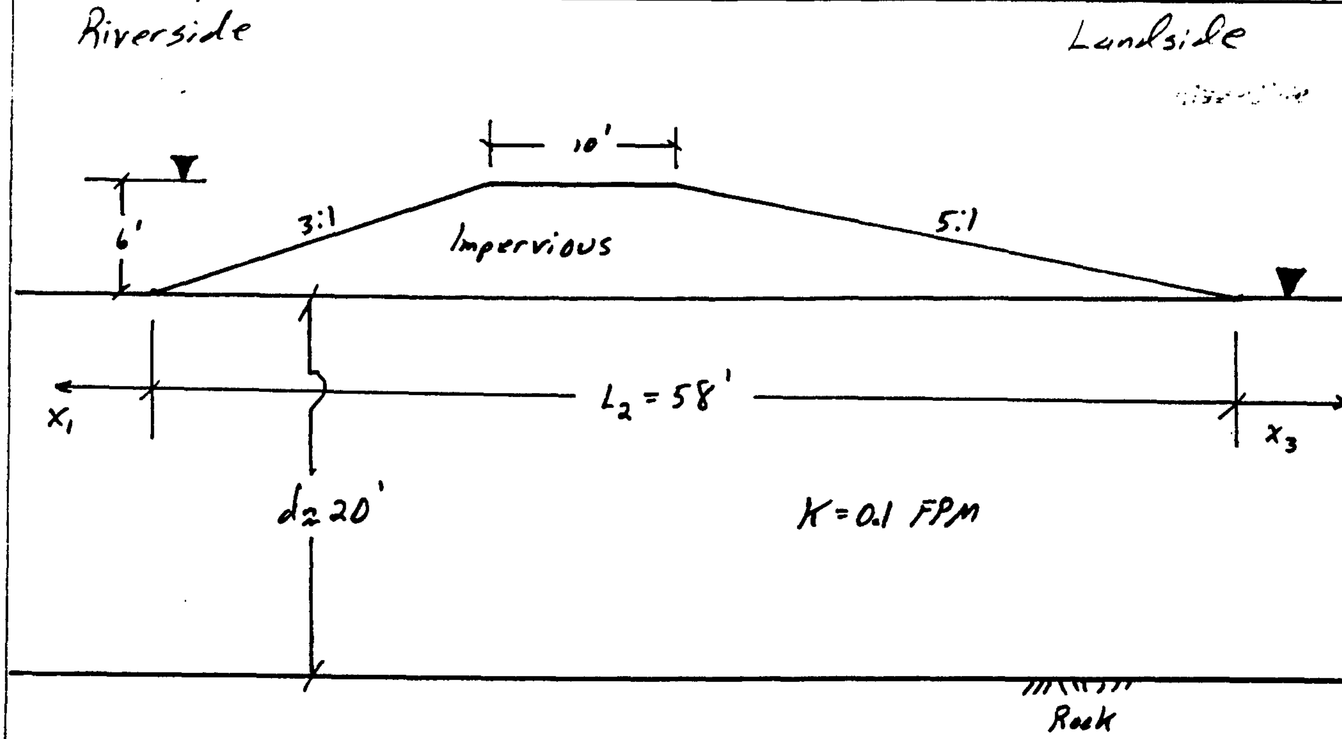
$N_F = 4 \quad , \quad N_d \approx 10$

$q = KH \frac{N_F}{N_d} = 0.1 \frac{Ft}{Min} (6') \left(\frac{4}{10}\right) = 0.24 \; Ft^3/min$ Per Ft

$= \underline{\underline{1.8 \; GPM/Ft}}$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Levee Seepage Analytical	COMPUTED BY: DAC	DATE: 11/22/91	FILE NO. ROCH DMb
	CHECKED BY:	DATE:	SHEET NO. 8



Reference EM 1913, Appendix B,

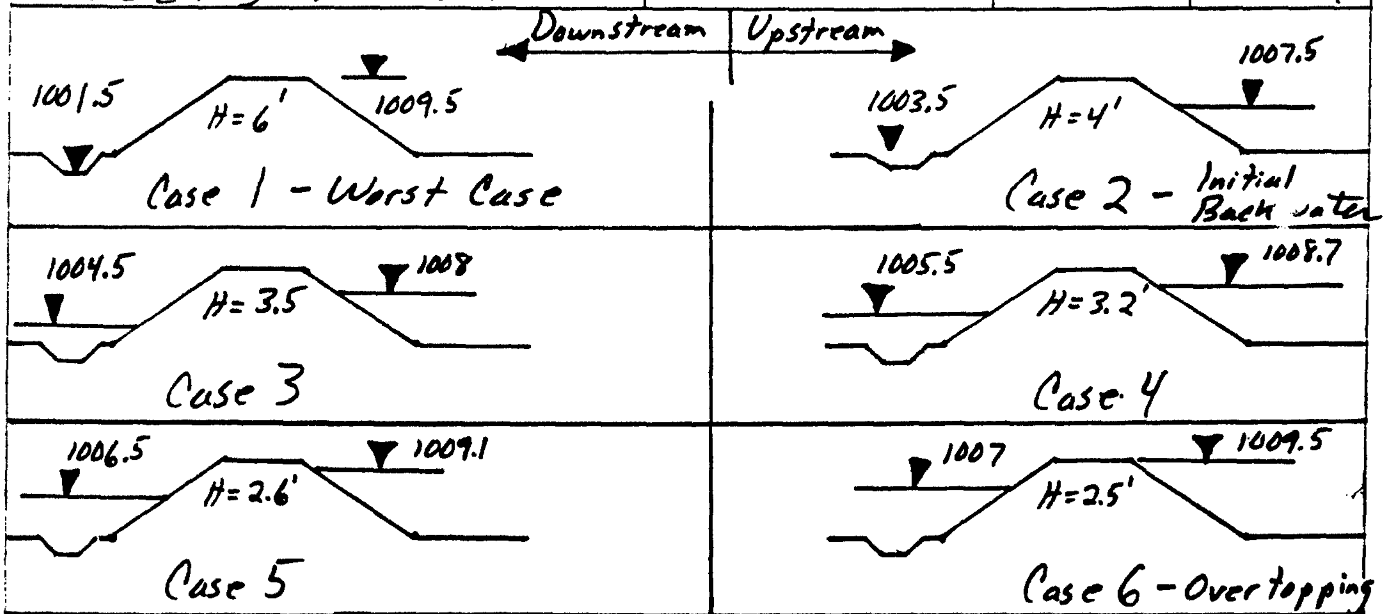
(Eqn. B-13) $\$ = \dfrac{d}{L_2 + 0.86d} = \dfrac{20}{58 + 0.86(20)} = \underline{\underline{0.266}}$

$Q = KH\$ = (0.1)(6')\,.266 = 0.160 \dfrac{Ft^3}{min}$ per Ft

$\underline{\underline{Q = 1.19\ GPM/Ft}}$

$i_{ave} = \dfrac{N_F H}{N_d\, d} = \dfrac{\$ H}{d} = \dfrac{(.266)\,6'}{20'} = 0.08 \quad < 0.3$ ✓ OK

WES FORM NO. 1253
REV OCT 1968



Case	Water Elev. (Ft) U/S	Water Elev. (Ft) D/S	SEEPS Coordinates U/S	SEEPS Coordinates D/S	Head (Feet)	Q * (Ft^3/MIN)	Shape Factor
1	1009.5	1001.5	26	18	8.0	.258	.323
2	1007.5	1003.5	24	20	4.0	.152	.380
3	1008.0	1004.5	24.5	21	3.5	.148	.423
4	1008.7	1005.5	25.2	22	3.2	.152	.478
5	1009.1	1006.5	25.6	23	2.6	.124	.477
6	1009.5	1007	26	23.5	2.5	.134	.536

* at $K_v = K_h = 0.1$ FPM, See Attached SEEPS Output for Case 1

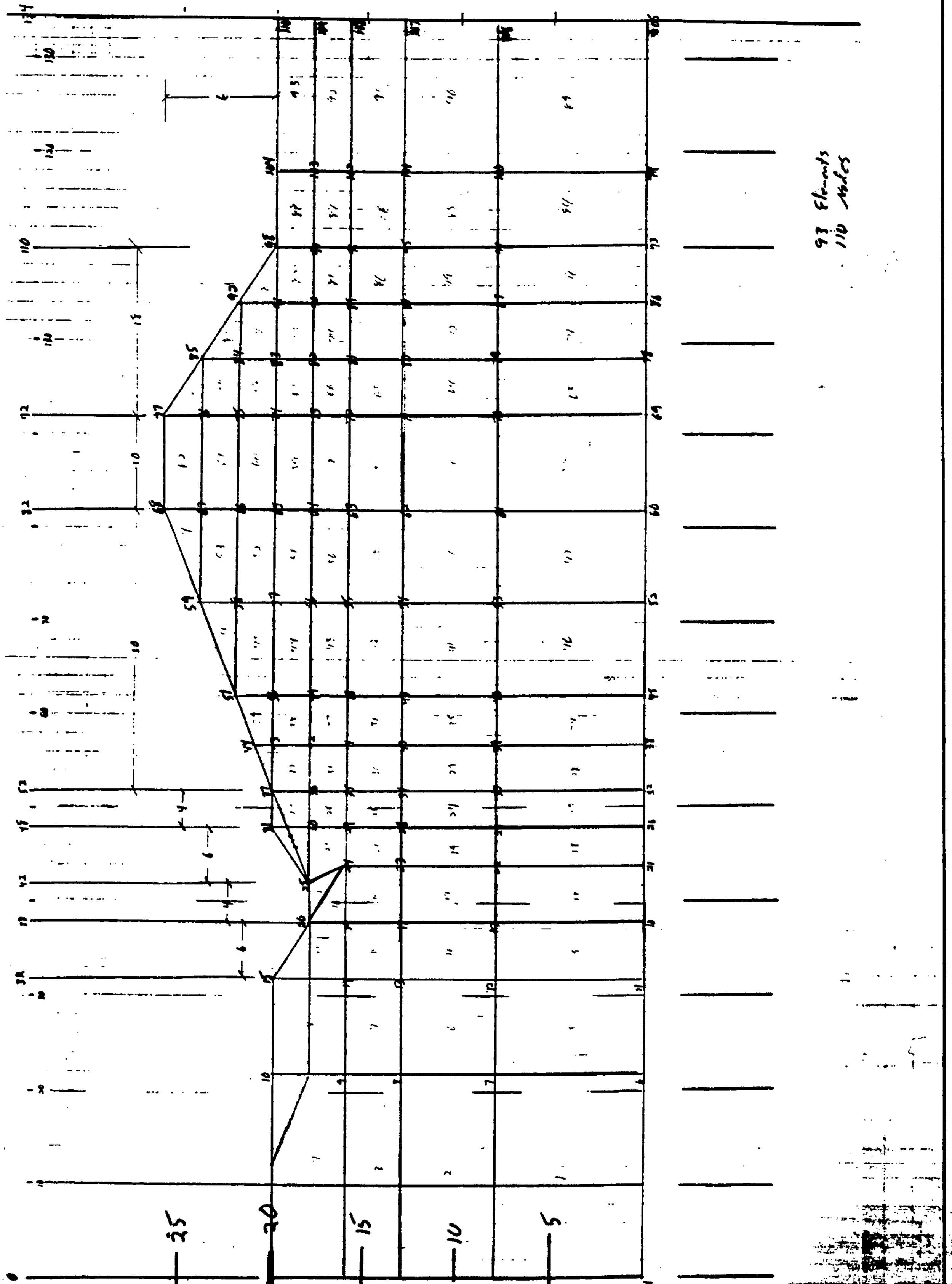
Consider Anisotropic Permeability, $K_h = .3$ FPM, $K_v = .1$ FPM

∴ Seepage increase by factor of about 2.5

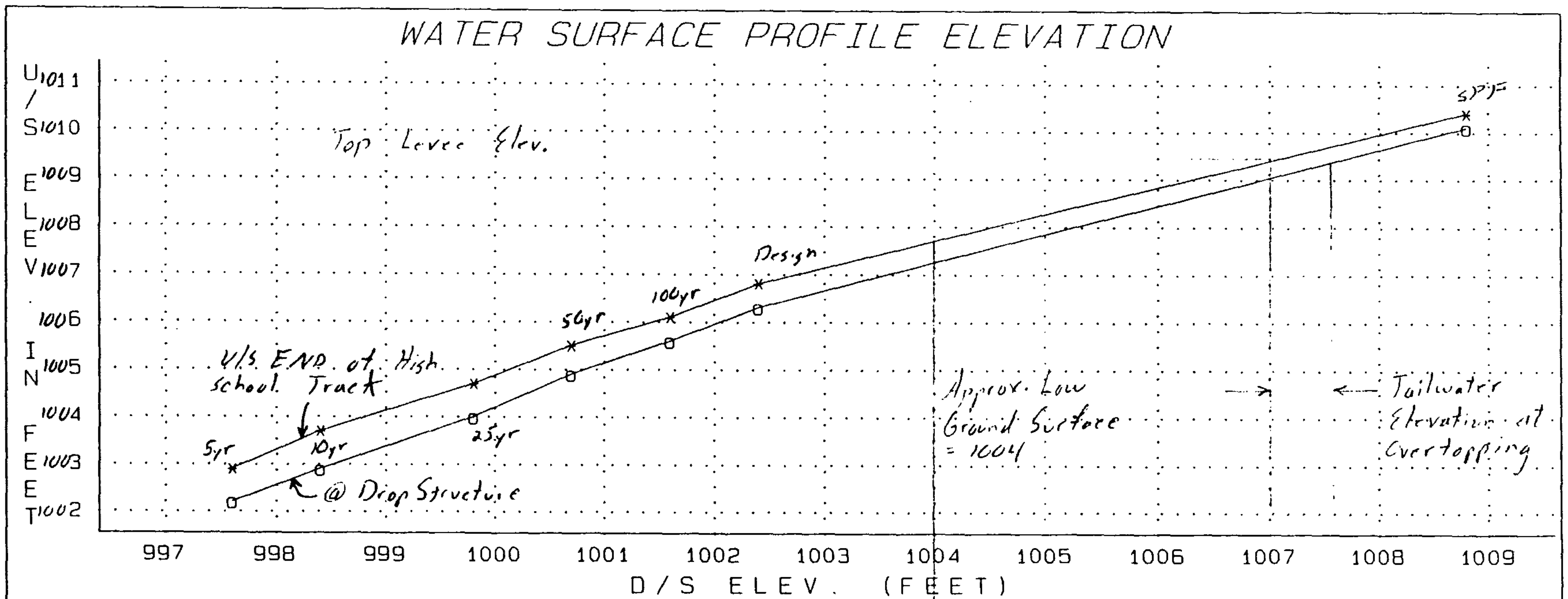
Case	Head	Q	Flow Ratio $\frac{Q \text{ at } K_h = .3}{Q \text{ at } K_h = .1}$
1	8.0	.656	2.54
2	4.0	.380	2.50
3	3.5	.366	2.47
4	3.2	.374	2.46
5	2.6	.306	2.47
6	2.5	.328	2.45

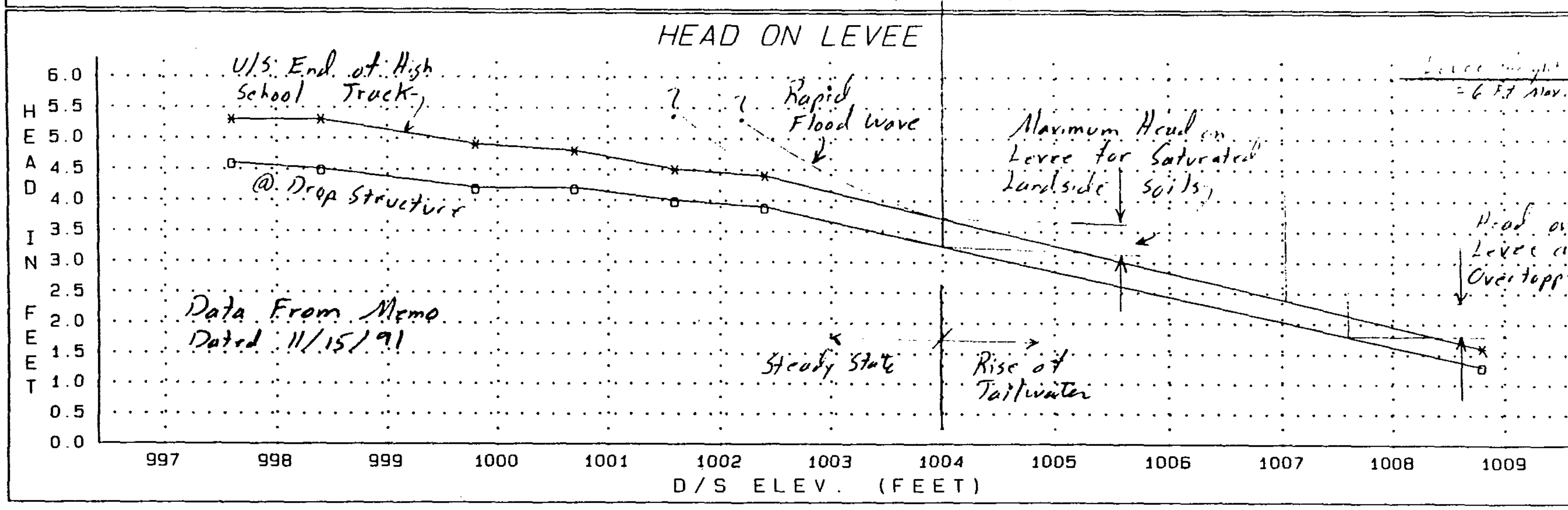
WES FORM NO. 1253
REV OCT 1968

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DH	DATE: 3/92	SHEET: 10
	SUBJECT TITLE: FEM Mesh	CHECKED BY:	DATE:	CONTRACT NO.: ROCHY DM-6



CENCS 23JAN92


WATER SURFACE PROFILE ELEVATION
U/S ELEV. IN FEET
1011
1010
1009
1008
1007
1006
1005
1004
1003
1002
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
D/S ELEV. (FEET)
Top Levee Elev.
SPF
Design
100yr
50yr
25yr
10yr
5yr
U/S END of High School Track
@ Drop Structure
Approx. Low Ground Surface = 1004
Tailwater Elevation at Overtopping


HEAD ON LEVEE
HEAD IN FEET
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
D/S ELEV. (FEET)
U/S End of High School Track
@ Drop Structure
Rapid Flood wave
Maximum Head on Levee for Saturated Landside soils
Head on Levee at Overtopping
= 6 Ft Max.
Steady State
Rise of Tailwater
Data From Memo Dated 11/15/91

SUBJECT: Levee	COMPUTED BY: DAC	DATE: 3/92	FILE NO. RUCH DM6
	CHECKED BY:	DATE:	SHEET NO. 12

Summary of Seepage Analyses

• For case I – Overtopping with NO tailwater

Analysis Method	Geometry	Seepage (CFM/LF) ②	Head (Feet)	Shape Factor ③
Analytic ①	Levee Only	0.160	6	0.27
Flow Net	↓	0.24	6	0.40
SEEPS	↓ ④	0.235	6	0.39
↓	Levee/Ditch ⑤	0.258	8	0.32
↓	Levee, Ditch and Trench ⑥	0.316	8	0.39

Notes:
① Applicable for impervious Levee Material – No Flow Thru Levee
② Permeability, $K_v = K_h = 0.1$ FPM
③ $\$ = Q / kh$
④ See attached output for file LEVEE2.*
⑤ See attached output for file LEVEE1.*
⑥ See attached output for file LEVEE4.*
⑦ See attached sketch for Drainage Trench configuration

Conclusion – For overtopping without tailwater, shape factors $\$ \leq 0.4$. From SEEPS analysis on previous page, $\$ > 0.4$ are observed for cases 3-6 where tailwater is ≥ 1 foot deep at Levee toe, but then heads are lower and seepage is less. Assume $\$ = 0.4$ should be conservative for total seepage estimate.

Summary of Piping Analyes

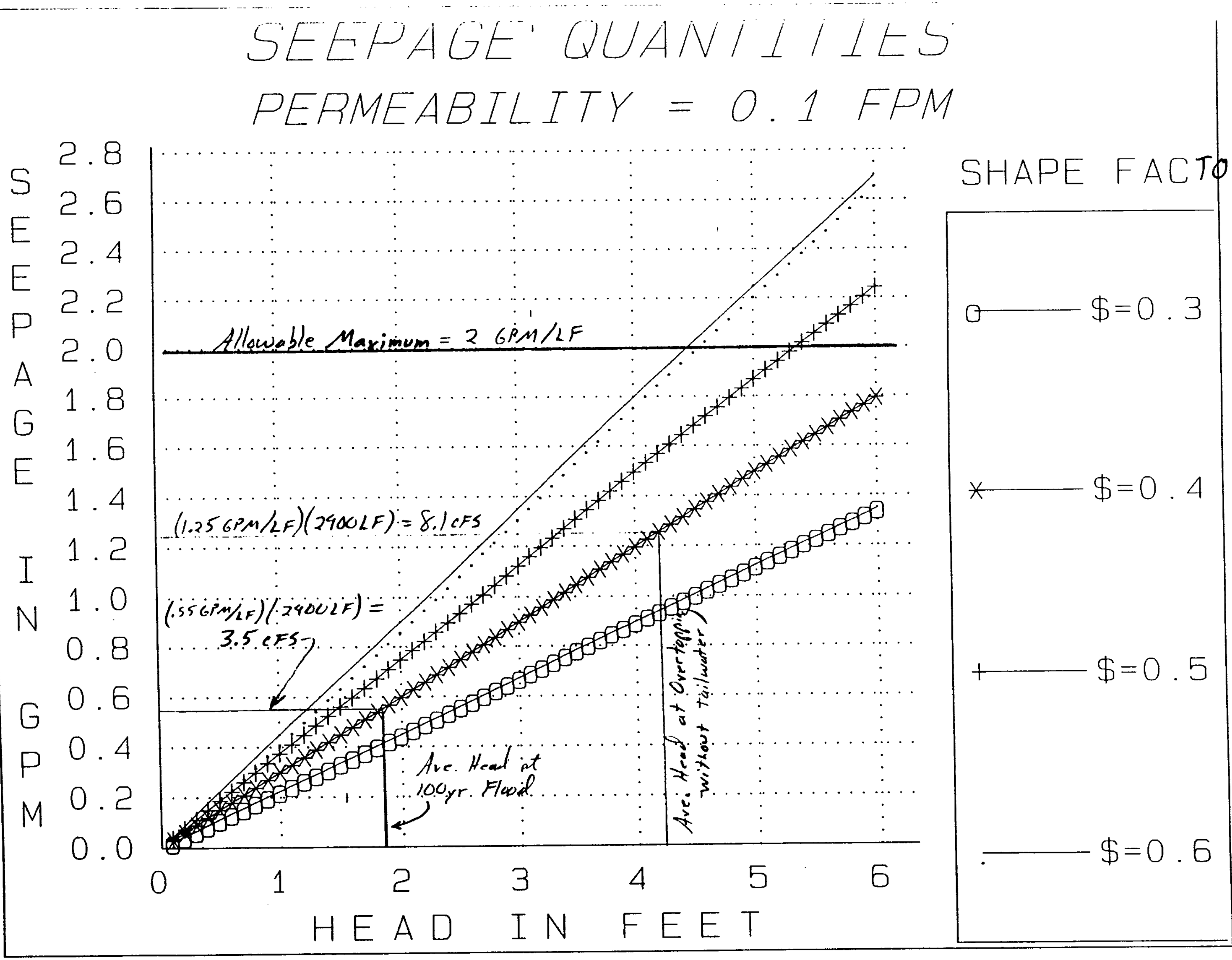
Method	Geometry	Ave. Gradient ⑧	Maximum Gradient At Toe ⑨
Analytic ①	Levee Only	0.08	—
Flow Net	↓	0.12	—
SEEPS	↓ ④	0.12	0.20
SEEPS	Levee/Ditch ⑤	0.13	0.25
SEEPS	Levee/Ditch/Trench ⑥	0.16	0.28

See Notes above also

⑧ $i_{ave} = N_F H / N_d D = \$ H / D$

⑨ See output Samples from SEEPS

WES FORM NO. 1253
REV OCT 1968


SEEPAGE QUANTITIES
PERMEABILITY = 0.1 FPM
SEEPAGE IN GPM
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
HEAD IN FEET
Allowable Maximum = 2 GPM/LF
(1.25 GPM/LF)(2900LF) = 8.1 CFS
(.55 GPM/LF)(2900LF) =
3.5 CFS
Ave. Head at
100yr. Flood
Ave. Head at Overtopping
without tailwater
SHAPE FACTOR
$=0.3
$=0.4
$=0.5
$=0.6

Levee Seepage Calculation: Left Bank

station	levee crest elev. (feet)	approx. ground surface elev. (feet)	100yr. flood water elev. (feet)	h: levee height (feet)	h: 100yr water above ground (feet)	ΔQ levee seepage: overtop ① (cfm)	ΔQ levee seepage: 100yr (cfm)
0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
70	n/a	n/a	n/a	n/a	n/a	n/a	n/a
200	1006.5	1000	1006.3	6.5	6.3	33.8	32.76
300	1006.5	1001.5	1006.3	5	4.8	20	19.2
400	1008.5	1002.5	1006.4	6	3.9	24	15.6
600	1008.6	1004	1006.4	4.6	2.4	36.8	19.2
800	1008.7	1004	1006.5	4.7	2.5	37.6	20
1000	1008.8	1004	1006.5	4.8	2.5	38.4	20
1200	1008.9	1004	1006.6	4.9	2.6	39.2	20.8
1400	1009.1	1004.2	1006.6	4.9	2.4	39.2	19.2
1600	1009.3	1004.5	1006.7	4.8	2.2	38.4	17.6
1800	1009.5	1005.5	1006.7	4	1.2	32	9.6
2000	1009.6	1005.5	1006.8	4.1	1.3	32.8	10.4
2200	1009.7	1006.5	1006.8	3.2	0.3	25.6	2.4
2400	1009.8	1006.7	1006.9	3.1	0.2	24.8	1.6
2600	1009.9	1006.7	1006.9	3.2	0.2	25.6	1.6
2800	1010	1006.7	1007	3.3	0.3	26.4	2.4
2900	1010.1	1007.5	1007	2.6	0	10.4	0
			total seepage (cfm) =			485	212.36
			total seepage (cfs) =			8.08333	3.53933

$$Q = \phi K h L$$

Assume $\phi \approx 0.4$, $K_v = K_h = 0.1$ FPM

$$Q = (.4)(.1)\, h L$$

L = Length along Levee

Note: ① Overtopping without Tailwater – Worst case

****

BEAR CREEK LEVEE, TYPICAL SECTION @STA. 4+00 - 12+00

****

file = LEVEE2.*

INPUT PROBLEM PARAMETERS

6' Levee - No Ditch

NUMBER OF NODES	110
NUMBER OF ELEMENTS.............	93
NUMBER OF DIFF MATERIALS......	1
PROB OPTION (0=AXI-SYMM ,1=PLANE)..	1
FIXED HEAD NODES (BC)	13
FIXED SEEPAGE NODES	0
HR VALUE	.600D+01

****

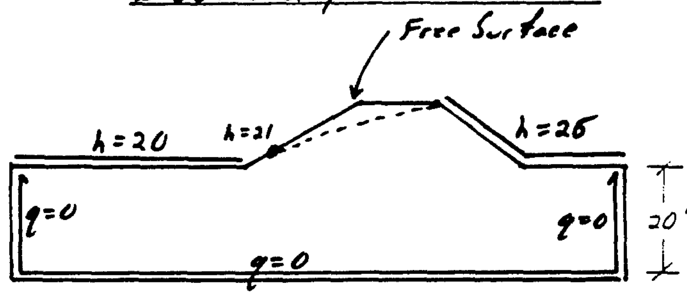
INPUT MATERIAL PROPERTIES

MATL	KXS	KYS [Ft/min]	ANG
1	.10D+00	.10D+00	.00D+00

BOUNDARY CONDITIONS

NODE	P/γ (Ft) PRESS HEAD	H (Ft) TOTAL HEAD
85	.200D+01	.260D+02
92	.400D+01	.260D+02
98	.600D+01	.260D+02
104	.600D+01	.260D+02
110	.600D+01	.260D+02
5	.000D+00	.200D+02
10	.000D+00	.200D+02
15	.000D+00	.200D+02
20	.000D+00	.200D+02
25	.000D+00	.200D+02
31	.000D+00	.200D+02
37	.000D+00	.200D+02
44	.000D+00	.210D+02

Boundary Conditions



NODAL PRESSURES AND SEEPAGE QUANTITIES

NODE	H (Ft) TOTAL HD	P/γ (Ft) PRESS HD
1	.200D+02	.200D+02
2	.200D+02	.120D+02
3	.200D+02	.701D+01
4	.200D+02	.401D+01
5	.200D+02	.000D+00
6	.201D+02	.201D+02
7	.201D+02	.121D+02
8	.201D+02	.705D+01
9	.200D+02	.403D+01
10	.200D+02	.000D+00
11	.202D+02	.202D+02
12	.202D+02	.122D+02
13	.201D+02	.713D+01
14	.201D+02	.407D+01
15	.200D+02	.000D+00
16	.204D+02	.204D+02

$$H = Z + P/\gamma + \cancel{\frac{V^2}{2g}}^{\,0}$$

17	.203D+02	.123D+02
18	.202D+02	.721D+01
19	.201D+02	.413D+01
20	.200D+02	.000D+00
21	.206D+02	.206D+02
22	.205D+02	.125D+02
23	.204D+02	.736D+01
24	.202D+02	.421D+01
25	.200D+02	.000D+00
26	.210D+02	.210D+02
27	.208D+02	.128D+02
28	.205D+02	.754D+01
29	.203D+02	.433D+01
30	.202D+02 -	.216D+01
31	.200D+02 -	.000D+00
32	.210D+02	.210D+02
33	.209D+02	.129D+02
34	.208D+02	.778D+01
35	.206D+02	.458D+01
36	.204D+02 -	.236D+01
37	.200D+02 -	.000D+00
38	.214D+02	.214D+02
39	.213D+02	.133D+02
40	.213D+02	.994D+01
41	.212D+02	.652D+01
42	.211D+02 -	.306D+01
43	.210D+02 -	.104D+01
44	.210D+02	.000D+00
45	.218D+02	.218D+02
46	.218D+02	.138D+02
47	.218D+02	.108D+02
48	.218D+02	.776D+01
49	.218D+02	.476D+01
50	.218D+02	.177D+01
51	.218D+02	-.175D+00
52	.228D+02	.228D+02
53	.228D+02	.148D+02
54	.228D+02	.118D+02
55	.228D+02	.882D+01
56	.228D+02	.584D+01
57	.229D+02	.288D+01
58	.229D+02	.911D+00
59	.229D+02	-.105D+01
60	.237D+02	.237D+02
61	.237D+02	.157D+02
62	.237D+02	.129D+02
63	.238D+02	.102D+02
64	.238D+02	.740D+01
65	.238D+02	.463D+01
66	.239D+02	.185D+01
67	.239D+02	-.120D+00
68	.239D+02	-.209D+01
69	.245D+02	.245D+02
70	.246D+02	.166D+02
71	.246D+02	.138D+02
72	.247D+02	.111D+02
73	.248D+02	.836D+01
74	.248D+02	.562D+01
75	.249D+02	.287D+01
76	.248D+02	.842D+00

16

$$i_{36-37} = \frac{.4-0}{2} = 0.2$$

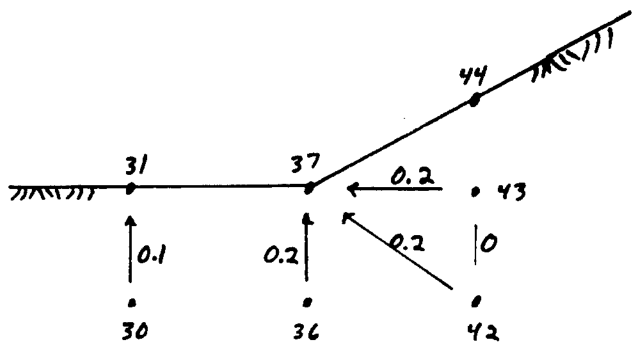
$$i_{42-43} = \frac{0}{2} = 0$$

$$i_{30-31} = \frac{.2}{2} = 0.10$$

$$i_{37-42} = \frac{1.[illegible]}{\sqrt{2^2+5^2}} = 0.20$$

$$i_{37-43} = \frac{1.0}{5} = 0.20$$

$$i < 0.3 \rightarrow OK$$



77	.248D+02	-.119D+01
78	.249D+02	.249D+02
79	.250D+02	.170D+02
80	.251D+02	.141D+02
81	.252D+02	.112D+02
82	.253D+02	.831D+01
83	.255D+02	.551D+01
84	.257D+02	.372D+01
85	.260D+02	.200D+01
86	.253D+02	.253D+02
87	.253D+02	.173D+02
88	.254D+02	.141D+02
89	.256D+02	.109D+02
90	.257D+02	.773D+01
91	.259D+02	.586D+01
92	.260D+02	.400D+01
93	.255D+02	.255D+02
94	.256D+02	.176D+02
95	.257D+02	.143D+02
96	.258D+02	.111D+02
97	.259D+02	.790D+01
98	.260D+02	.600D+01
99	.257D+02	.257D+02
100	.258D+02	.178D+02
101	.259D+02	.129D+02
102	.259D+02	.992D+01
103	.260D+02	.796D+01
104	.260D+02	.600D+01
105	.259D+02	.259D+02
106	.259D+02	.179D+02
107	.259D+02	.129D+02
108	.260D+02	.996D+01
109	.260D+02	.798D+01
110	.260D+02	.600D+01

****

SEEPAGE QUANTITIES

****

NODE	SEEPAGE
85	.105D+00
92	.544D-01
98	.375D-01
104	.268D-01
110	.113D-01
5	-.438D-02
10	-.125D-01
15	-.150D-01
20	-.127D-01
25	-.280D-01
31	-.474D-01
37	-.877D-01
44	-.276D-01

SEEPAGE IN= .235D+00 SEEPAGE OUT =-.235D+00 [Ft^3/MIN]

Q = 1.76 GPM / Ft

****

BEAR CREEK, TYPICAL LEVEE SECTION @STA. 4+00 - 12+00   File = LEVEE1.*

****

****

INPUT PROBLEM PARAMETERS

NUMBER OF NODES	110
NUMBER OF ELEMENTS.............	93
NUMBER OF DIFF MATERIALS......	1
PROB OPTION (0=AXI-SYMM ,1=PLANE)..	1
FIXED HEAD NODES (BC)	8
FIXED SEEPAGE NODES	0
HR VALUE	.600D+01

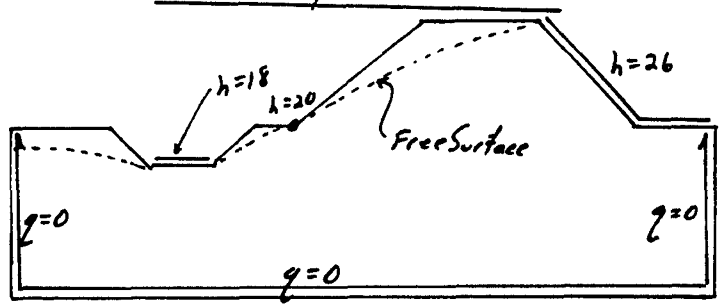
6' Levee
2' Ditch

****

INPUT MATERIAL PROPERTIES

MATL	KXS	KYS	ANG
1	.10D+00	.10D+00	.00D+00

Boundary Conditions



BOUNDARY CONDITIONS

NODE	P/γ (Ft) PRESS HEAD	H (Ft) TOTAL HEAD
85	.200D+01	.260D+02
92	.400D+01	.260D+02
98	.600D+01	.260D+02
104	.600D+01	.260D+02
110	.600D+01	.260D+02
20	.000D+00	.180D+02
25	.000D+00	.180D+02
37	.000D+00	.200D+02

NODAL PRESSURES AND SEEPAGE QUANTITIES

NODE	H (Ft) TOTAL HD	P/γ (Ft) PRESS HD
1	.188D+02	.188D+02
2	.188D+02	.108D+02
3	.188D+02	.579D+01
4	.188D+02	.279D+01
5	.188D+02	-.120D+01
6	.188D+02	.188D+02
7	.188D+02	.108D+02
8	.188D+02	.578D+01
9	.188D+02	.278D+01
10	.188D+02	-.124D+01
11	.190D+02	.190D+02
12	.189D+02	.109D+02
13	.187D+02	.571D+01
14	.186D+02	.264D+01
15	.187D+02	-.133D+01
16	.192D+02	.192D+02
17	.190D+02	.110D+02
18	.187D+02	.570D+01
19	.184D+02	.237D+01
20	.180D+02	.000D+00
21	.196D+02	.196D+02
22	.194D+02	.114D+02

23	.191D+02	.609D+01
24	.187D+02	.270D+01
25	.180D+02	.000D+00
26	.202D+02	.202D+02
27	.199D+02	.119D+02
28	.196D+02	.661D+01
29	.195D+02	.351D+01
30	.195D+02	.153D+01
31	.196D+02	-.408D+00
32	.202D+02	.202D+02
33	.202D+02	.122D+02
34	.201D+02	.714D+01
35	.201D+02	.410D+01
36	.201D+02	.207D+01
37	.200D+02	.000D+00
38	.208D+02	.208D+02
39	.208D+02	.128D+02
40	.208D+02	.942D+01
41	.208D+02	.610D+01
42	.208D+02	.279D+01
43	.208D+02	.839D+00
44	.209D+02	-.135D+00
45	.213D+02	.213D+02
46	.213D+02	.133D+02
47	.214D+02	.104D+02
48	.214D+02	.738D+01
49	.214D+02	.441D+01
50	.215D+02	.146D+01
51	.215D+02	-.493D+00
52	.224D+02	.224D+02
53	.225D+02	.145D+02
54	.225D+02	.115D+02
55	.225D+02	.851D+01
56	.225D+02	.555D+01
57	.226D+02	.259D+01
58	.226D+02	.629D+00
59	.227D+02	-.133D+01
60	.235D+02	.235D+02
61	.235D+02	.155D+02
62	.235D+02	.127D+02
63	.236D+02	.996D+01
64	.236D+02	.719D+01
65	.236D+02	.442D+01
66	.236D+02	.165D+01
67	.237D+02	-.322D+00
68	.237D+02	-.229D+01
69	.244D+02	.244D+02
70	.244D+02	.164D+02
71	.245D+02	.137D+02
72	.246D+02	.110D+02
73	.246D+02	.823D+01
74	.247D+02	.551D+01
75	.248D+02	.276D+01
76	.247D+02	.731D+00
77	.247D+02	-.131D+01
78	.248D+02	.248D+02
79	.249D+02	.169D+02
80	.250D+02	.140D+02
81	.251D+02	.111D+02
82	.252D+02	.825D+01

$$i_{24-25} = \frac{.7}{\sqrt{2^2+2^2}} = 0.25$$

$$i_{24-23} = \frac{.4}{3} = 0.13$$

$$i_{19-20} = \frac{.4}{2} = 0.2$$

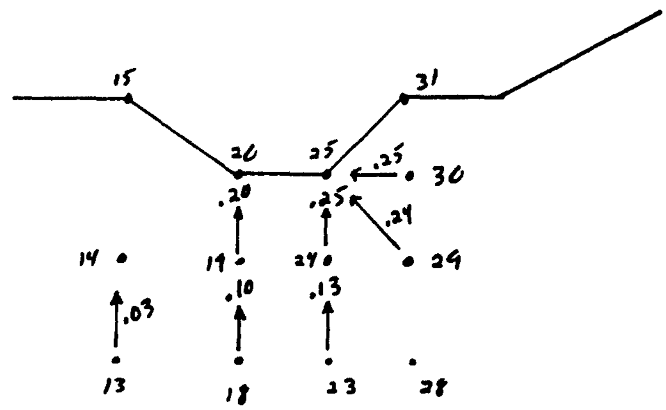
$$i_{14-18} = \frac{.3}{3} = 0.1$$

$$i_{25-30} = \frac{1.5}{6} = 0.25$$

$$i_{25-29} = \frac{1.5}{\sqrt{2^2+6^2}} \quad 0.24$$

$$i_{13-14} = \frac{0.1}{3} = 0.03$$

$$i < 0.3 \rightarrow OK$$



83	.255D+02	.546D+01
84	.257D+02	.369D+01
85	.260D+02	.200D+01
86	.252D+02	.252D+02
87	.253D+02	.173D+02
88	.254D+02	.140D+02
89	.255D+02	.108D+02
90	.257D+02	.771D+01
91	.259D+02	.585D+01
92	.260D+02	.400D+01
93	.255D+02	.255D+02
94	.255D+02	.175D+02
95	.256D+02	.143D+02
96	.257D+02	.111D+02
97	.259D+02	.789D+01
98	.260D+02	.600D+01
99	.257D+02	.257D+02
100	.258D+02	.178D+02
101	.258D+02	.128D+02
102	.259D+02	.991D+01
103	.260D+02	.795D+01
104	.260D+02	.600D+01
105	.259D+02	.259D+02
106	.259D+02	.179D+02
107	.259D+02	.129D+02
108	.260D+02	.995D+01
109	.260D+02	.798D+01
110	.260D+02	.600D+01

****

SEEPAGE QUANTITIES

****

NODE	SEEPAGE
85	.115D+00
92	.597D-01
98	.412D-01
104	.294D-01
110	.124D-01
20	-.697D-01
25	-.169D+00
37	-.194D-01

SEEPAGE IN= .258D+00 SEEPAGE OUT =-.258D+00 [Ft³/min]

Q= 1.93 GPM /Ft < 2.0

OK

```
******************************************************************************
BEAR CREEK LEVEE, TYPICAL SECTION @STA. 4+00 - 12+00
******************************************************************************
******************************************************************************
```

file = LEVEE4.*

INPUT PROBLEM PARAMETERS

```
     NUMBER OF NODES          .........  110
     NUMBER OF ELEMENTS.............      93
     NUMBER OF DIFF  MATERIALS......       2
 PROB OPTION (0=AXI-SYMM ,1=PLANE)..       1
     FIXED HEAD NODES (BC) .........       7
     FIXED SEEPAGE NODES ...........       0
     HR VALUE ......................  .600D+01
******************************************************************************
```

6' Levee
2' Ditch
2' Granular Relief Trench

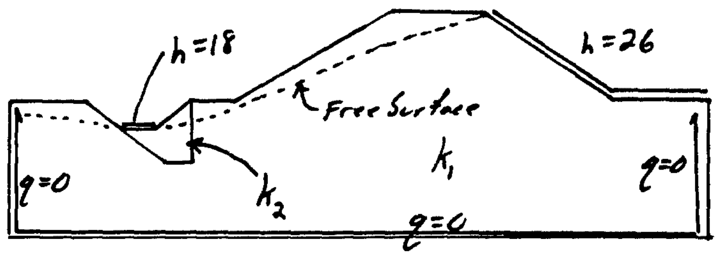
INPUT MATERIAL PROPERTIES

MATL	KXS	KYS [FPM]	ANG
1	.10D+00	.10D+00	.00D+00
2	.10D+02	.10D+02	.00D+00

BOUNDARY CONDITIONS

NODE	P/γ (Ft) PRESS HEAD	H (Ft) TOTAL HEAD
85	.200D+01	.260D+02
92	.400D+01	.260D+02
98	.600D+01	.260D+02
104	.600D+01	.260D+02
110	.600D+01	.260D+02
20	.000D+00	.180D+02
25	.000D+00	.180D+02

Boundary Conditions



NODAL PRESSURES AND SEEPAGE QUANTITIES

NODE	H (Ft) TOTAL HD	P/γ (Ft) PRESS HD
1	.184D+02	.184D+02
2	.184D+02	.104D+02
3	.184D+02	.536D+01
4	.184D+02	.236D+01
5	.184D+02	-.163D+01
6	.184D+02	.184D+02
7	.184D+02	.104D+02
8	.184D+02	.536D+01
9	.184D+02	.235D+01
10	.183D+02	-.165D+01
11	.185D+02	.185D+02
12	.184D+02	.104D+02
13	.183D+02	.532D+01
14	.183D+02	.228D+01
15	.183D+02	-.170D+01
16	.186D+02	.186D+02
17	.185D+02	.105D+02
18	.183D+02	.528D+01
19	.181D+02	.214D+01
20	.180D+02	.000D+00
21	.189D+02	.189D+02

22	.187D+02	.107D+02
23	.183D+02	.534D+01
24	.180D+02	.201D+01
25	.180D+02	.000D+00
26	.195D+02	.195D+02
27	.191D+02	.111D+02
28	.187D+02	.567D+01
29	.180D+02	.204D+01
30	.180D+02	.370D-01
31	.180D+02	-.196D+01
32	.195D+02	.195D+02
33	.194D+02	.114D+02
34	.192D+02	.618D+01
35	.191D+02	.309D+01
36	.190D+02	.103D+01
37	.190D+02	-.957D+00
38	.200D+02	.200D+02
39	.200D+02	.120D+02
40	.200D+02	.863D+01
41	.199D+02	.527D+01
42	.200D+02	.195D+01
43	.200D+02	-.294D-02
44	.200D+02	-.972D+00
45	.206D+02	.206D+02
46	.206D+02	.126D+02
47	.206D+02	.965D+01
48	.207D+02	.667D+01
49	.207D+02	.370D+01
50	.208D+02	.752D+00
51	.208D+02	-.120D+01
52	.219D+02	.219D+02
53	.219D+02	.139D+02
54	.219D+02	.109D+02
55	.220D+02	.798D+01
56	.220D+02	.502D+01
57	.221D+02	.207D+01
58	.221D+02	.114D+00
59	.222D+02	-.184D+01
60	.231D+02	.231D+02
61	.231D+02	.151D+02
62	.232D+02	.124D+02
63	.232D+02	.959D+01
64	.232D+02	.682D+01
65	.233D+02	.406D+01
66	.233D+02	.129D+01
67	.233D+02	-.671D+00
68	.234D+02	-.263D+01
69	.241D+02	.241D+02
70	.242D+02	.162D+02
71	.243D+02	.135D+02
72	.243D+02	.107D+02
73	.244D+02	.803D+01
74	.245D+02	.532D+01
75	.246D+02	.257D+01
76	.245D+02	.543D+00
77	.245D+02	-.150D+01
78	.246D+02	.246D+02
79	.247D+02	.167D+02
80	.248D+02	.138D+02
81	.250D+02	.110D+02

$$i_{30-36} = \frac{1.0}{4} = .25$$

$$i_{25-30} = \frac{0}{6} = 0$$

$$i_{29-25} = \frac{0}{\sqrt{6^2+2^2}} = 0$$

$$i_{29-35} = \frac{1.1}{4} = .28$$

$$i_{29-34} = \frac{1.2}{\sqrt{4^2+3^2}} = .24$$

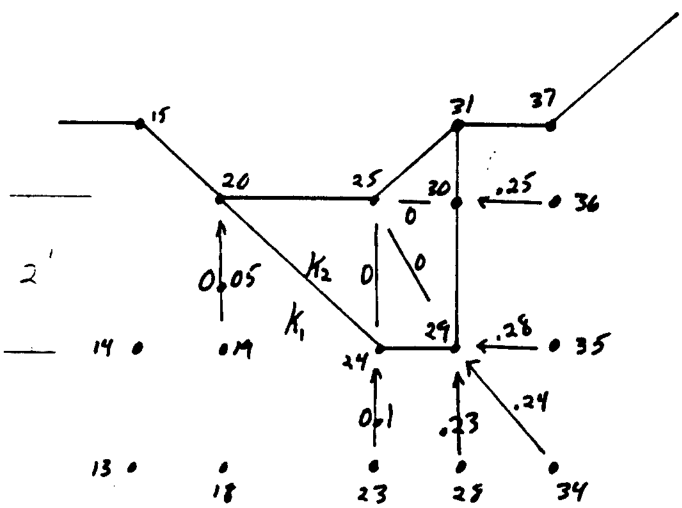
$$i_{29-28} = \frac{0.7}{3} = .23$$

$$i_{23-24} = \frac{0.3}{3} = 0.1$$

$$i_{24-25} = \frac{0}{\sqrt{2^2+2^2}} = 0$$

$$i_{14-20} = \frac{0.1}{2} = 0.05$$

$i < 0.3 \rightarrow$ OK



$K_2/K_1 = 100$

82	.251D+02	.813D+01
83	.254D+02	.538D+01
84	.256D+02	.365D+01
85	.260D+02	.200D+01
86	.251D+02	.251D+02
87	.252D+02	.172D+02
88	.253D+02	.139D+02
89	.254D+02	.108D+02
90	.257D+02	.766D+01
91	.258D+02	.583D+01
92	.260D+02	.400D+01
93	.254D+02	.254D+02
94	.255D+02	.175D+02
95	.256D+02	.142D+02
96	.257D+02	.110D+02
97	.259D+02	.787D+01
98	.260D+02	.600D+01
99	.257D+02	.257D+02
100	.257D+02	.177D+02
101	.258D+02	.128D+02
102	.259D+02	.989D+01
103	.259D+02	.795D+01
104	.260D+02	.600D+01
105	.258D+02	.258D+02
106	.259D+02	.179D+02
107	.259D+02	.129D+02
108	.259D+02	.995D+01
109	.260D+02	.797D+01
110	.260D+02	.600D+01

****
SEEPAGE QUANTITIES
****

NODE	SEEPAGE
85	.133D+00
92	.686D-01
98	.474D-01
104	.338D-01
110	.143D-01
20	.190D-01
25	-.316D+00

SEEPAGE IN= .316D+00 SEEPAGE OUT =-.316D+00 (Ft^3/min)

Q = 2.4 GPM / Ft > 2.0

Acceptible Because: 1) Unusual / Extreme Head Conditions

2) Flow into Relief Trench

APPENDIX C

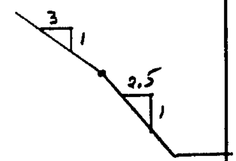
GEOTECHNICAL DESIGN

COMPUTATIONS FOR SLOPE STABILITY

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAL	DATE: 4/14/92	SHEET: 1
	SUBJECT TITLE: Slope Stability	CHECKED BY:	DATE:	CONTRACT NO.: ROCH 4 DM6

Slope Stability

1) Assume Critical Section: use broken slope with lower half 2.5H:1V and upper half 3H:1V. Typical Section near sta. 10+00 to 33+00.



2) Use Soil parameters adopted for Bear Creek, included in 4 November 1991 memo:

$c = 0$ $\phi = 33^\circ$

$\gamma_{moist} = 115\,pcf$ $\gamma_{sat.} = 125\,pcf$ ← Simplified 115 used in UTexas2

3) Factor of Safety for Infinite Slope (shallow slide)

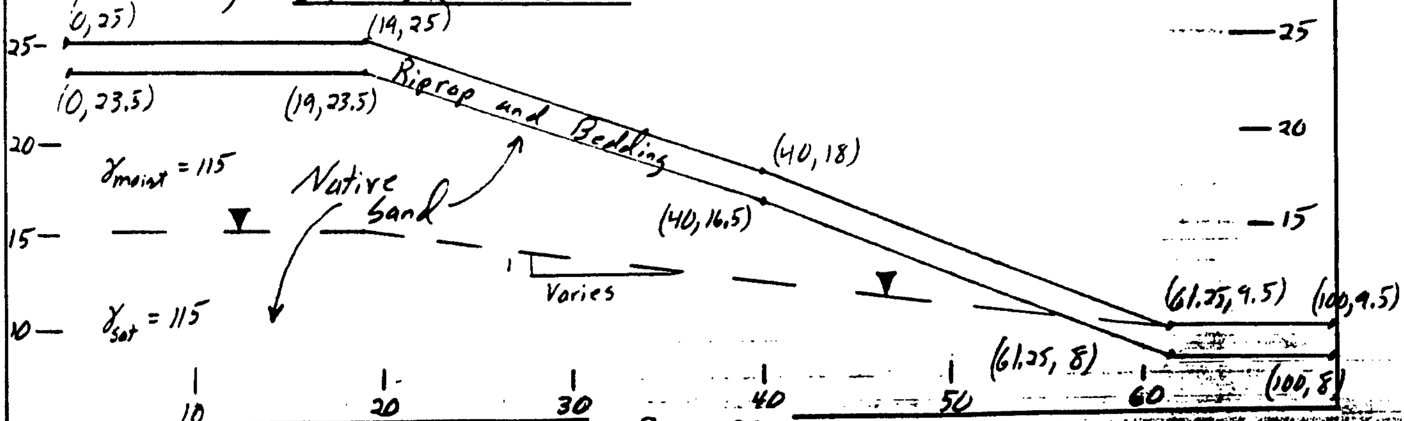
$$FS = \frac{\tan\phi}{\tan\beta} = \frac{\tan 33^\circ}{(1/2.5)} = 1.62$$

4) Factor of Safety for Sloughing at Slope toe during Construction, Assume Infinite Slope and seepage parallel to slope (wet surface, no suction). Reference EM 1110-2-1902 "Stability of Earth + Rockfill Dams", p. V-1:

$$FS = \frac{\tan\phi}{\tan\beta}\left(\frac{\gamma'}{\gamma_{sat.}}\right) = 1.62\left(\frac{125-62.4}{125}\right) = 0.81 \rightarrow \text{Unstable}$$

∴ Expect sloughing at toe where dewatering does not lower water level below slope face and temporary invert level during construction. Use method of slices to determine stability post-construction with riprap cover.

5) UTexas2 Model



CENCS 23JAN92

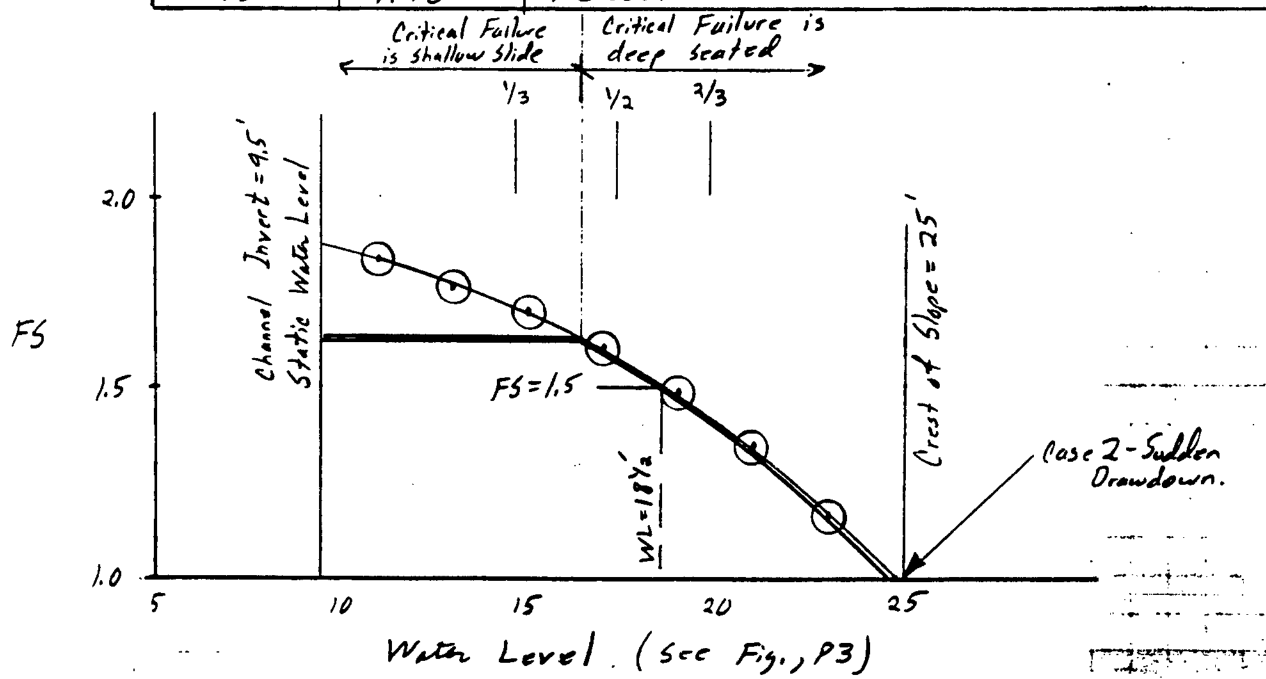
US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAE	DATE: 4/14/92	SHEET: 2
	SUBJECT TITLE: Slope Stability	CHECKED BY:	DATE:	CONTRACT NO.:

5) Assume 1½ feet riprap and bedding that is significantly more permeable than underlying sand. Assume constant drainage of riprap and bedding, so there is No pore pressure in upper 1½ feet on slope surface.

6) UTexas 2 results for Spencers Method:

Factor of Safety will vary dependent on static water profile in slope. Assume linear profile from point below slope crest and extending thru toe of slope (see figure, p. 3).

Water Level	Factor of Safety	Data File	Comments
11	(1.83)	PZ11.*	Non-Critical, Surface forced tangent to Elev = 8. Critical Surface is Shallow Slide.
13	(1.77)	PZ13.*	
15	(1.70)	PZ15.*	
17	1.60	PZ17.*	Critical Surface
19	1.49	PZ19.*	
21	1.35	PZ21.*	
23	1.16	PZ23.*	

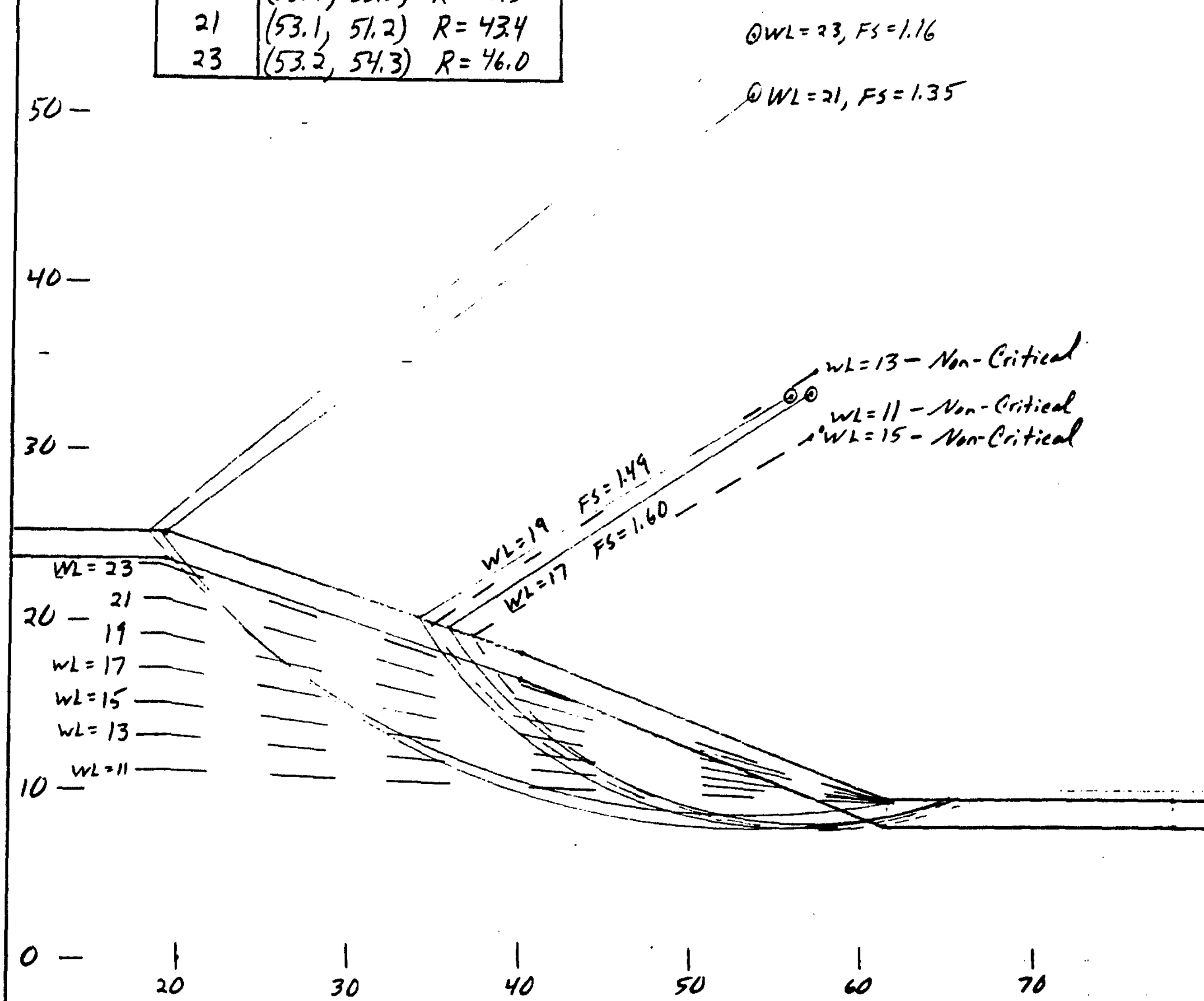


CENCS 23JAN92

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAC	DATE: 4/14/92	SHEET: 3
	SUBJECT TITLE: Slope Stability	CHECKED BY:	DATE:	CONTRACT NO.: ROCHY DM 6

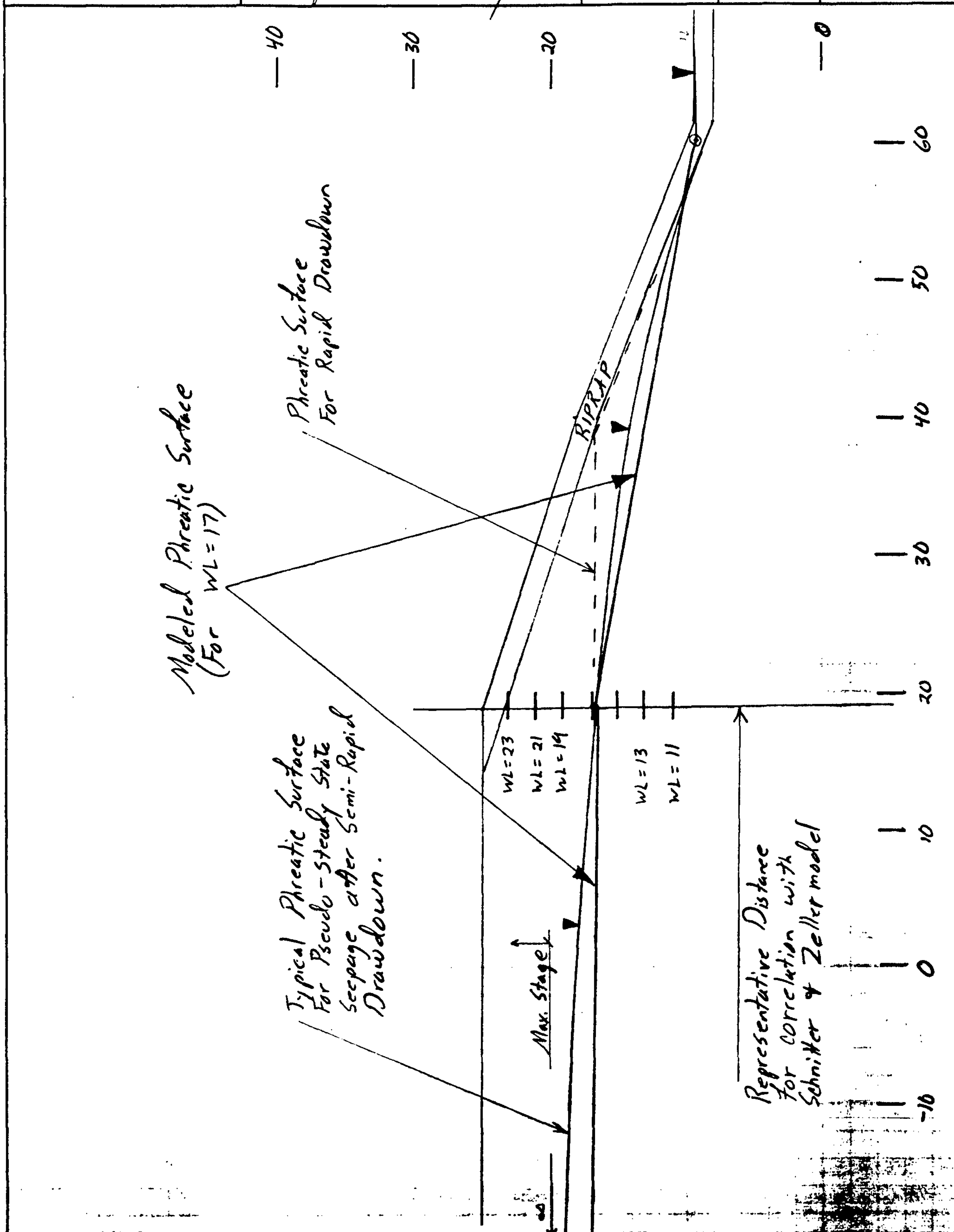
Failure Surfaces

Water Level	Circle
11	(57.1, 31.2) R = 23.2
13	(56.8, 34.8) R = 26.8
15	(56.6, 30.6) R = 22.6
17	(56.4, 31.4) R = 23.2
19	(55.9, 33.5) R = 25.3
21	(53.1, 51.2) R = 43.4
23	(53.2, 54.3) R = 46.0



CENCS 23JAN92

US Army Corps of Engineers	PROJECT TITLE: Bear Creek	COMPUTED BY: DAC	DATE: 4/15/92	SHEET: 3A
Saint Paul District	SUBJECT TITLE: Slope Stability	CHECKED BY:	DATE:	CONTRACT NO.: ROCH4 DM6



CENCS 23JAN92

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAC	DATE: 1/15/92	SHEET: 4
	SUBJECT TITLE: Slope Stability	CHECKED BY:	DATE:	CONTRACT NO.: X0CH4 DM6

7) Estimate Seepage Line During Drawdown

Ref: EM 1110-2-1902, Appendix III

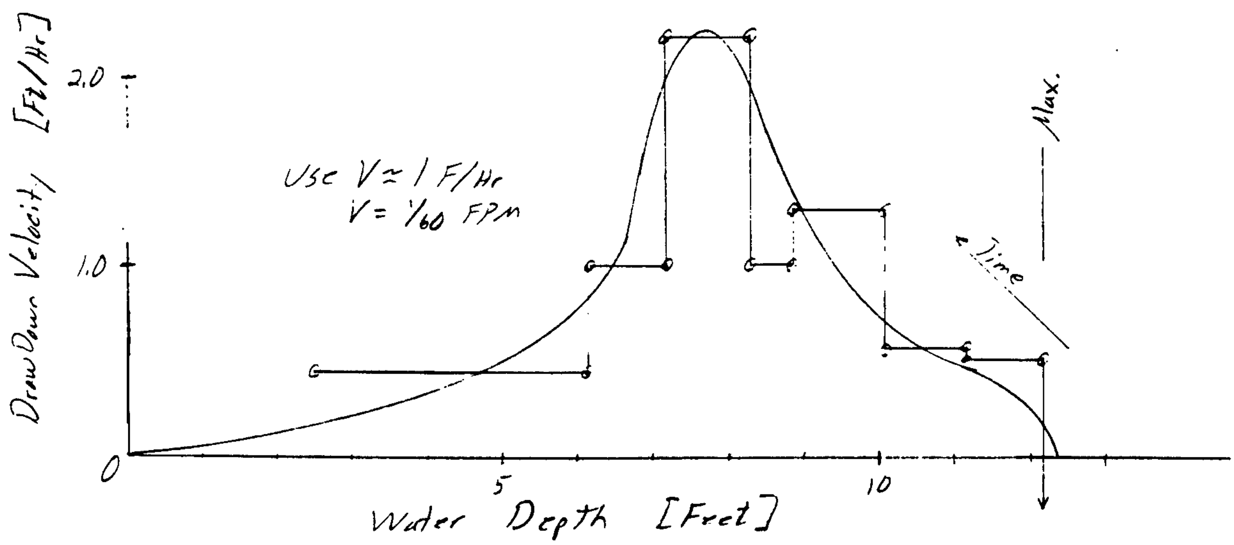
Assume method by Schnitter & Zeller for pervious shell against an impervious core. For a high amount of infiltration and steady steepage in addition to drawdown, this will be non-conservative. However, for the design flood, the river stages rise rapidly and are maintained for short duration and then fall again. The river stages for the design flood will likely rise above the ground water level, causing flow from the river into the banks. A flow gradient requires that the water level in the banks will never reach the maximum river stage. This, compounded with the duration of high stages being near the same time duration as the drawdown period would lead to a conservative analysis. Assume the seepage is: 1) due primarily to rise of river stages, 2) feed by high water level near river banks only and not extending a long distance landside due to short duration of high water, 3) approximated by method of Schnitter + Zeller.

Hydrograph Data ①			HEC-2 Data ②		Draw Down Velocity Computations	
Flow Rate Q [CFS]	Time T [Hrs]	ΔT [Hrs]	River Stage [Feet]	Water Depth ③ H [Feet]	ΔH [Feet]	$\frac{\Delta H}{\Delta T}$ [FPM]
.000	34.0		≈ 981	≈ 2.5		
		8.5			3.7	0.44
3400	25.5		984.7	6.2		
		1.0			1.0	1.0
4300	24.5		985.7	7.2		
		0.5			1.1	2.2
5400	24.0		986.8	8.3		
		0.5			0.5	1.0
5900	23.5		987.3	8.8		
		1.0			1.3	1.3
7200	22.5		988.6	10.1		
		2.0			1.1	0.55
8500	20.5		989.7	11.2		
		2.0			1.0	0.5
9700	18.5		990.7	12.2		

CENCS 23JAN92

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAE	DATE: 4/14/92	SHEET: 5
	SUBJECT TITLE: Slope Stability	CHECKED BY:	DATE:	CONTRACT NO.: ROCH 4 DM6

Notes: ① From GDM, plate D-6. For Bear Creek at Hwy 14 (sta. 62+00).
② From rating curve at Sta. 15+20, HEC2 model.
③ Invert Elev. = 978.5.



Soil Parameters: $\gamma_{sat} = 125\,pcf$, $\gamma_m = 115\,pcf$, $e = 0.69$

Assume $G_s = 2.7$

$$w_{sat} = \frac{Se}{G} = \frac{1(.69)}{2.7} = 25\%$$

$$\gamma^d = \gamma_{sat}/w_{sat} = 125/1.25 = 100\,pcf$$

$$w_m = \gamma_m/\gamma_d = 115/100 = 15\%$$

$$n = e/(1+e)$$

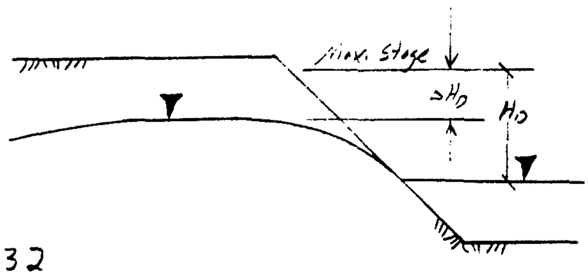
$$n_e = n\left(\frac{w_s - w_m}{w_s}\right) = \left(\frac{.69}{1.69}\right)\left(\frac{25-15}{25}\right) = \underline{\underline{0.16}}$$

For most native sands, permeability was estimated fm levee and drop structure seepage as ≈ 0.1 FPM.

$$P_D = \frac{K}{n_e V} = \frac{0.1\ FPM}{(.16)(V)}$$, X vs. P_D is on EM 1902, Plate III-1

CENCS 23JAN92

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DH	DATE: 4/15/92	SHEET: 6
	SUBJECT TITLE: Slope Stability	CHECKED BY:	DATE:	CONTRACT NO.: ROCHY DM 6



For Max. Stage (9700 cFS) to 3400 cFS,

$\bar{V} = \frac{dh}{dt} = \frac{6\,Ft}{7\,Hrs}$, $P_D = \frac{(.1)\,60}{(.16)(6/7)} = 32$

$X = 22$, $H_D - \Delta H_D = (.22)(6') = 1.3'$

For Max. Stage (9700 cFS) to 1000 cFS,

$\bar{V} = 9.7'/15.5$, $P_D = \frac{(.1)\,60}{(.16)\,9.7/15.5} = 60$

$X = 16$, $H_D - \Delta H_D = (.16)(9.7') = 1.6'$

Determine minimum acceptable permeability of sand in bank:

Use FS = 1.5, From graph on sheet 2, WL in UTexas 2 model = 18.5

$(H_D - \Delta H_D) = 18.5 - 9.5 = 9\,Ft$

From Chart on sheet 4, max. river stage = 12.2 Ft = H_D

$X = 9/12.2 = 74\%$, Assume Drawdown Velocity = 1 FPM

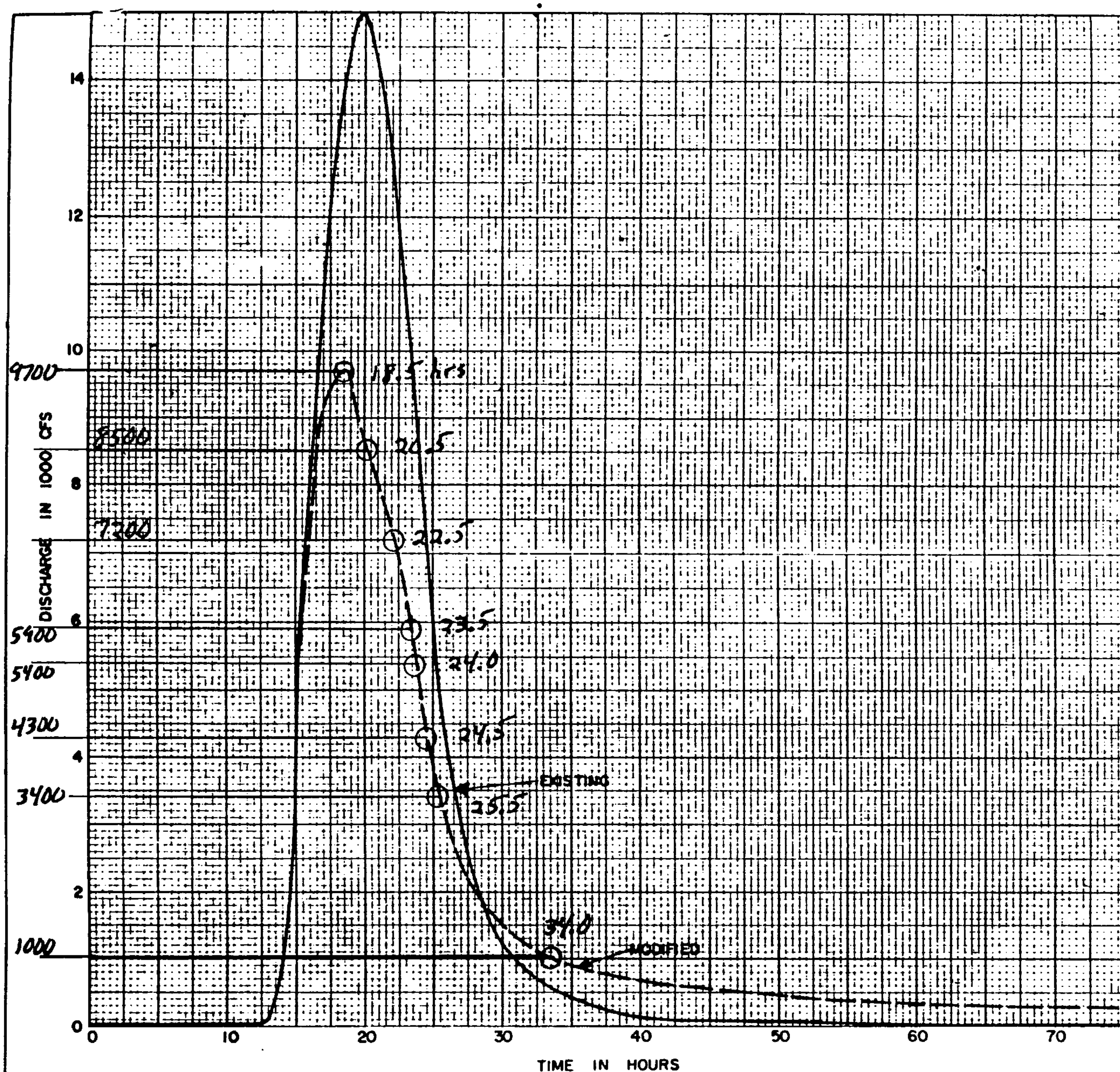
$P_D = 1.4$, $P_D = \frac{K}{n_e V} = \frac{K}{(.16)(1/60)\,FPM} = 1.4$

$K \geq 3.7 \times 10^{-3}\,FPM \approx 1.9 \times 10^{-3}\,cm/sec$

From Hazen, $K \approx D_{10}^2$, $D_{10} \geq 0.04\,mm$

From Grain size analysis tests, all (SP), (SP-SM) and (SM-SP) soils had $D_{10} \geq .04$ mm. Only (SM) soils will not meet this criteria. Most of the (SM) soils are existing fill and are typically near the surface. There are some areas of (SC) and (CL) soils, but there is not enough of these soils, nor test data to generalize characteristics, strength parameters & to include in analysis.

CENCS 23JAN92



FLOOD CONTROL - ZUMBRO RIVER
ROCHESTER, MINNESOTA
PHASE II
GENERAL DESIGN MEMORANDUM

DESIGN FLOOD

BEAR CREEK AT HWY. 14 & 52

ST. PAUL, MINNESOTA DISTRICT

File No. M 30-R-5/39

PLATE

```
HEADING
     Bear creek channel banks.
     Typical section.
     Case A - Steady state seapage
PROFILE LINES
     2     2     RIPRAP
     0     23.5
     19    23.5
     40    16.5
     61.25     8
     100   8

     1     1     NATIVE SAND
     0           25
     19          25
     40          18
     61.25       9.5
     100         9.5


MATERIAL PROPERTIES
     1           RIPRAP
     115
     CONV
     0     33
     NO PORE PRESSURE
     2           NATIVE SAND
     115
     CONVENTIONAL SHEAR STRENGTH
     0     33
     PIEZOMETRIC LINE
     1

PIEZOMETRIC LINE DATA
     1     62.4 WATER TABLE
     0     17
     20    17                    water level changes in input files.
     60    9.5
     100   9.5


ANALYSIS/COMPUTATION
     CIRCULAR SEARCH
     40    50    0.1   0
     TANGENT
     8

COMPUTE                          - Include "STOP" in files
                                   PZ11.* , PZ13.* + PZ15.*
```

APPENDIX C

GEOTECHNICAL DESIGN

SOIL PARAMETERS

INTRODUCTION

THE SUBSURFACE INVESTIGATION FOR THE BEAR CREEK REACH HAS RESULTED IN 42 BORINGS BEING PERFORMED. TEN BORINGS WERE COMPLETED IN 1981 FOR COMPLETION OF THE GDM, WITH THE REMAINING 32 BORINGS COMPLETED IN LATE SUMMER OF 1989. THIRTY ONE BORINGS ARE NEAR MAJOR PROJECT FEATURES, WHILE 11 BORINGS WERE PERFORMED FOR THE U/S LEVEES.

BEAR CREEK CHANNEL IMPROVEMENTS WILL RESULT IN THE EXISTING CHANNEL BEING MADE WIDER AND DEEPER, WITH THE RESULTING STRUCTURES AND SLOPES BEING AFFECTED. STRUCTURES INCLUDE FOOTBRIDGES, TWO DROP STRUCTURES, WALLS, AND BRIDGE MODIFICATIONS, ALONG WITH THE U/S TIE BACK LEVEE SYSTEM.

A DETERMINATION OF SOIL PARAMETERS TO BE USED IN DESIGNING THE STRUCTURES AND LEVEES NEEDS TO BE COMPLETED.

PURPOSE

THIS DOCUMENT WILL ANALYZE THE SOIL BORINGS TO DETERMINE THE SOIL PARAMETERS TO USE FOR THE DESIGN OF THE STRUCTURES AND THE LEVEES.

METHODOLOGY

IN GENERAL, THE SOIL PARAMETERS WILL BE DETERMINED USING THE SPT BLOW COUNTS IN A GIVEN RANGE OF ELEVATIONS (TRANSLATES TO DEPTH BELOW THE GROUND SURFACE). INITIAL THOUGHTS WERE TO CONTINUE THE DATA BASE FOR DIRECT SHEAR TESTING IN ROCHESTER, BUT THE COE BORING CREW GEOLOGIST DID NOT HAVE GREAT CONFIDENCE IN THE SAMPLES WHICH WERE OBTAINED FOR THE DIRECT SHEAR TESTS.

THE USE OF THE SPT BLOW COUNTS, N, COMBINED WITH EFFECTIVE STRESS AT THE DEPTH OF THE SPT, CAN BE CORRELATED TO FIND RELATIVE DENSITY, DR (NAVFACS, DM 7.1, pg 87). THE DR AND USCS SOIL CLASSIFICATION CAN BE CORRELATED TO THE APPROXIMATE Ø ANGLE, ALONG WITH AN ESTIMATE OF δ_D, e, AND n (NAVFACS, DM 7.1, pg 149). THE LATTER PARAMETERS ALLOW FOR A DETERMINATION OF γ_{SAT}.

THE RESULTING SOIL PARAMETERS WILL BE COMPARED TO THE RESULTS OF SEVERAL DIRECT SHEAR TESTS RUN FOR OTHER REACHES OF THE SURVEY PROJECT AND THE RESULTS OF SPT vs N vs DR ANALYSES FOR OTHER REACHES.

NOTE: THE SOILS FOR THIS REACH CONSIST OF MOSTLY SP, SM, AND SP-SM SOILS. SEVERAL CL AND CH CLAY SEAMS WERE FOUND IN THE LEVEE AREAS. THE CLAY SOILS FOUND NEAR STRUCTURES ARE NOT ANTICIPATED TO AFFECT THE PERFORMANCE OF THE STRUCTURES.

FOR DESIGN PURPOSES, ASSUME C = 0 PSF, UNLESS SPECIFIED ELSEWHERE.

SELECTION OF BORINGS

SEVERAL SCHOOLS OF THOUGHT EXIST FOR THE SELECTION OF WHICH BORINGS TO USE FOR AN SPT vs N vs DR ANALYSIS:

1) FOR EACH STRUCTURE, USE THE BORINGS IN THE IMMEDIATE VICINITY OF THE STRUCTURE

2) USE AN OVERALL ANALYSIS FOR DETERMINING Ø FOR STRUCTURES BY USING ALL BORINGS NEAR ALL STRUCTURES AND DETERMINE A DESIGN Ø FOR THE REACH. IN ADDITION, USE ALL "BANK" BORINGS FOR DETERMINING Ø FOR SLOPE STABILITY CONDITIONS.

3) USE ALL BORINGS TO DETERMINE A DESIGN Ø FOR THE REACH FOR ALL ANALYSES - STRUCTURAL AND SLOPE STABILITY

FOR THIS REACH, A COMBINATION OF ALL THREE METHODS WILL BE USED. THIS IS DUE TO THE FACT THAT ALMOST ALL BORINGS TAKEN FOR THE STRUCTURES WERE TAKEN IN THE BANK OR WITHIN THE LIMITS OF THE NEW CHANNEL, DUE TO THE ACCESS RESTRICTIONS. THEREFORE, ALL BORINGS WILL BE USED TO DETERMINE A DESIGN Ø FOR THE REACH (EXCEPT LEVEES). THE LEVEES ARE FAR REMOVED FROM MOST OF THE MAJOR STRUCTURES. THE SOILS IN THIS AREA WILL BE ANALYZED ON A SEPARATE BASIS.

HOWEVER, THE BORINGS FOR EACH FEATURE WILL BE EXAMINED ON A CASE BY CASE BASIS TO LOOK FOR ANOMOLIES THAT MAY NOT SATISFY THE ASSUMPTION PRESENTED HEREIN.

ELEVATION LIMITS

THE SELECTION OF ELEVATION LIMITS IS BASED ON DESIGN CHANNEL BOTTOM, AS SHOWN IN THE GDM. THE DESIGN CHANNEL BOTTOM RANGES FROM ELEVATION 970 TO 990, WITH BANK ELEVATIONS RANGING FROM 980 TO 1000 (DESIGN WATER + F.B.).

MOST OF THE CHANNEL WILL HAVE A ROCK BOTTOM AND PARTIAL ROCK SLOPES, WITH A RELATIVELY THIN (10-20 FT) OVERBURDEN OVERLYING THE ROCK.

SUMMARY OF SELECTED BORINGS

ALL SPT RESULTS FOR ALL BORINGS, EXCEPT FOR THE LEVEE BORINGS, WILL BE USED. THE LEVEE BORINGS MAY ALSO BE USED TO EXPAND THE DATA BASE.

ASSUMPTIONS

IN ORDER TO DETERMINE ~~THE EFFECTIVE~~ OVERBURDEN STRESS, AN ESTIMATE OF γ_{MOIST} AND γ_{SAT} NEEDS TO BE MADE.

THE 2A REACH AND CASCADE CREEK REACH USED

INSITU: $\gamma_m = 115$ PCF
$\gamma_s = 122$ PCF

RANDOM FILL: $\gamma_m = 120$ PCF
$\gamma_s = 130$ PCF

→ USE THE VALUES FOR RANDOM FILL AND CHECK ASSUMPTION LATER FOR VALIDITY.

SOIL BORING DATA

SPT data is included on the Boring Logs. An example of the data reduction for SPT - Friction Angle correlation is given on the following page.

THE DR VALUES WERE SELECTED TO THE NEAREST 5%. THIS IS DUE TO THE RESULTS FOR CASCADE CREEK, WHICH GAVE NEARLY IDENTICAL RESULTS FOR AN AVERAGE DR FOR "EXACT" VALUES OF DR SELECTED FROM THE NAVFACS CHART OR FOR ROUNDED VALUES OF DR.

Rochester

Bear Creek — Soil Parameters — [illegible] — 3/26/90 — 5/

Boring #	G.S. Elev	G.W. Elev	Depth, FT	σ_v', KSF ±	N	Dr, %	Comments
81-32M 3+50	983.4	977.9 (5.50')	4	0.48	8	60	ML IN FIELD
			9	0.90	5	40	
			14	1.24	22	85	
			19	1.58	8	45	
			24	1.92	24	80	
			28	2.19	51		ROCK FRAGMENTS
89-244M 6+00	988.8	977.9 (11.40')	4	0.48	12	10	SC
			9	1.08	6	45	SC
			14	1.54	6	40	
81-31M 7+00	990.0	978.3 (11.70')	4	0.48	20	90	
			9	1.08	10	60	ML
			14	1.56	2	10	
			19	1.90	17	65	
			24	2.24	36	90	
			29	2.57	28	80	
			34	2.91	31	80	
			39	3.25	43	85	

STATISTICAL ANALYSIS

A BRIEF STATISTICAL ANALYSIS WAS PERFORMED ON THE DATA. THREE DATA SETS WERE ANALYZED:

1) ALL BORINGS EXCLUSIVE OF THOSE BORINGS TAKEN SPECIFICALLY FOR THE LEVEES

2) ALL BORINGS

3) THE LEVEE BORINGS ONLY.

RELATIVE DENSITY STATISTICS

DATA SET	MEAN, $\bar{x}$	STD DEV, σ	
1	63.32	16.86	$n = 101$
2	65.35	16.17	$n = 143$
3	70.24	13.34	$n = 42$

THE ATTACHED HISTOGRAMS INDICATE THAT 2/3 OF THE VALUES IN EACH CASE FALL AT OR ABOVE A RELATIVE DENSITY OF 60%.

USE $D_R = 60\%$.

FROM NAVFACS, ($7.1.149)

$\phi = 33^\circ$

$\gamma_D = 99$ PCF

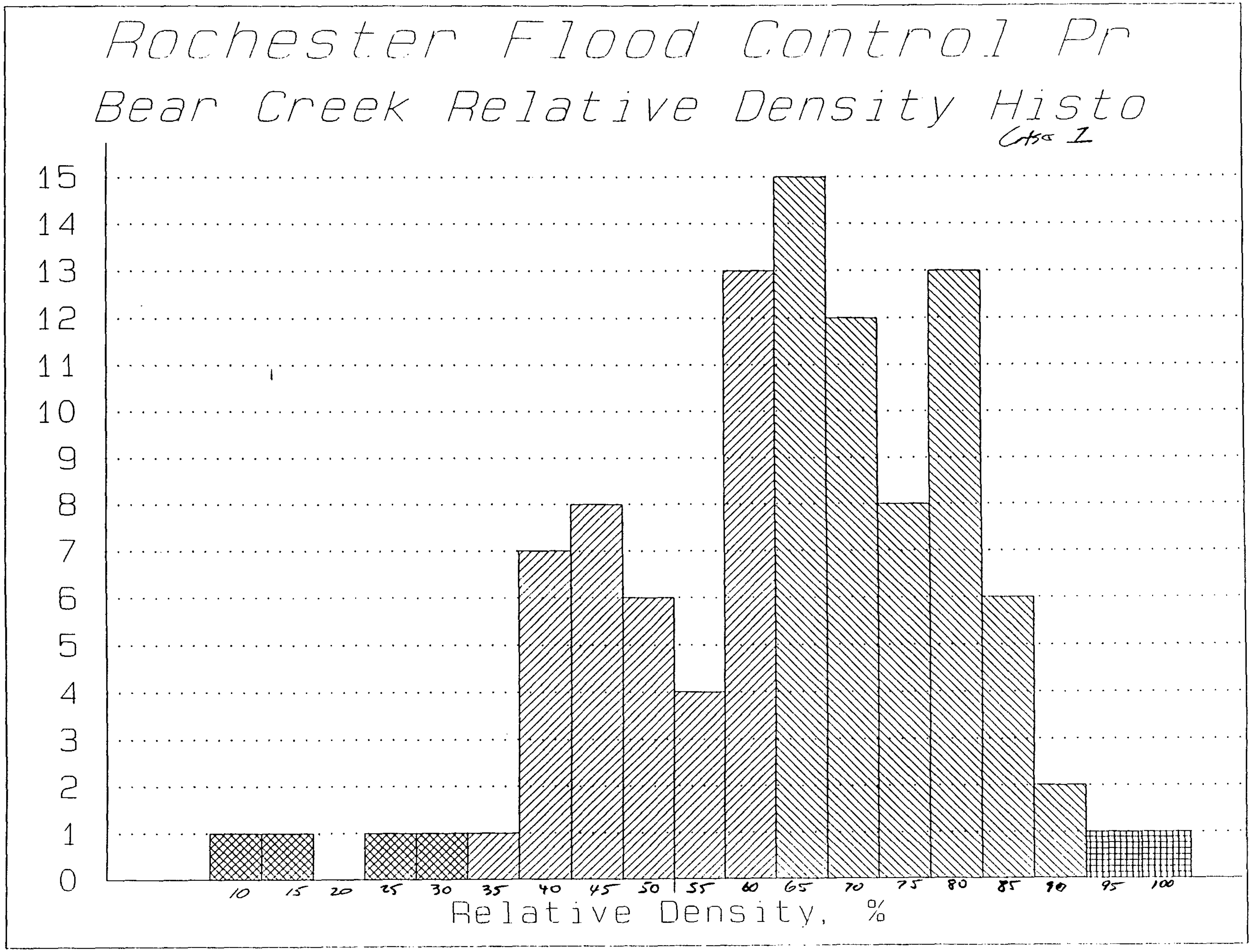
$e = 0.69$

$\gamma_{SAT} = 125$ PCF

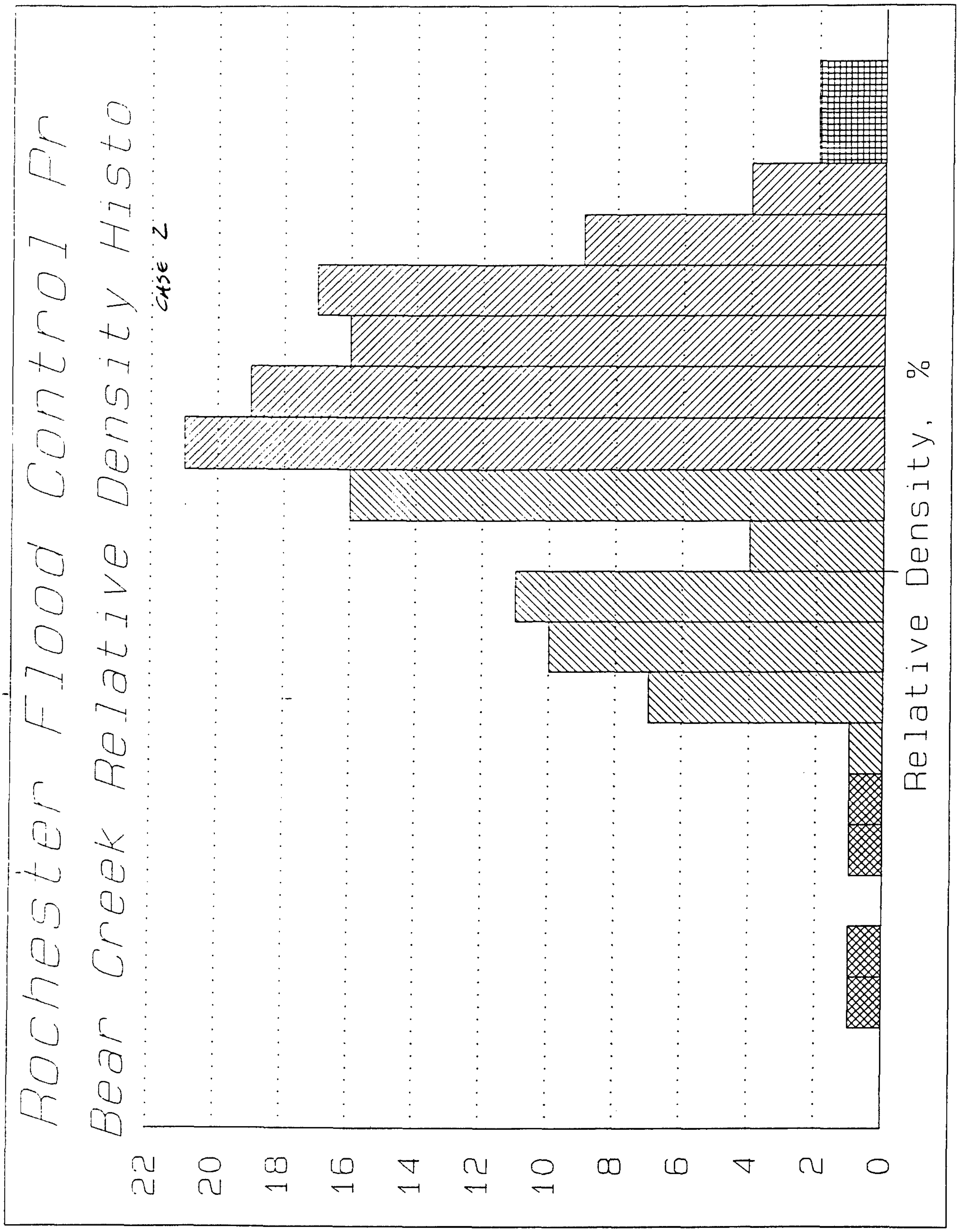
$\gamma_{MOIST} = 115$ PCF

Rochester Flood Control Project
Bear Creek
Soil Parameter Analysis
Relative Density Histogram
Case 1 -- Soil Borings w/o Levee Borings
Case 2 -- All Borings
Case 3 -- Levee Borings Only

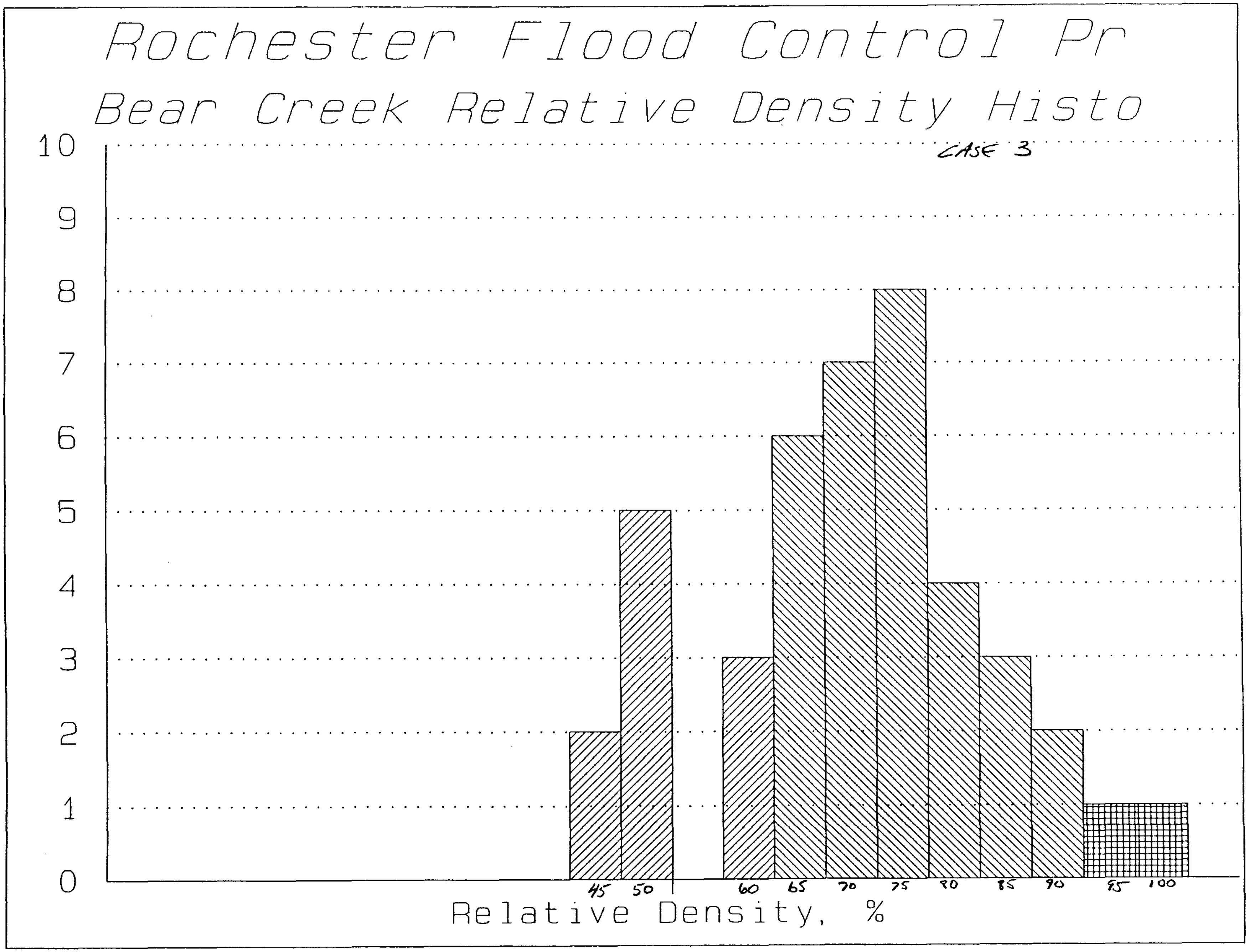
	Case 1	Case 2	Case 3
Dr, %	N	N	N
5	0	0	0
10	1	1	0
15	1	1	0
20	0	0	0
25	1	1	0
30	1	1	0
35	1	1	0
40	7	7	0
45	8	10	2
50	6	11	5
55	4	4	0
60	13	16	3
65	15	21	6
70	12	19	7
75	8	16	8
80	13	17	4
85	6	9	3
90	2	4	2
95	1	2	1
100	1	2	1


Rochester Flood Control Pr
Bear Creek Relative Density Histo
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Relative Density, %

9



Rochester Flood Control Pr
Bear Creek Relative Density Histo
CASE 2
Relative Density, %
0
2
4
6
8
10
12
14
16
18
20
22



Rochester Flood Control Pr
Bear Creek Relative Density Histo
CASE 3
10
9
8
7
6
5
4
3
2
1
0
45
50
60
65
70
75
80
85
90
95
100
Relative Density, %

TABLE C-

SUMMARY OF UNCONFINED COMPRESSION TESTS ON ROCK

Soil Boring No.	Sample Depth ft	Sample Elevation ft	Rock Type	Unconfined Compressive Strength, psi
88-137M	22.0	967.8	Limestone	2,920
88-138M	11.0	985.1	Limestone, sandy	15,860
88-139M	13.0	983.1	Limestone	8,130
88-139M	24.0	972.1	Limestone	2,080
88-140M	16.0	981.1	Limestone, sandy	3,130
88-199M	22.0	966.0	Limestone	2,620
88-202M	30.5	965.6	Limestone	5,450
88-203M	7.0	975.0	Limestone	5,220
88-203M	11.5	970.5	Limestone	5,250
88-204M	17.3	979.1	Limestone	4,580
88-204M	22.5	973.9	Limestone, shaly	6,700
88-204M	28.0	968.4	Limestone	9,120

$n = 12$
$\bar{x} = 5922$
$s = 3813$

SUBJECT: Bear Creek Rock Quality	COMPUTED BY: DAC	DATE: 3/3/92	FILE NO. Rock 4 DM-6
	CHECKED BY:	DATE:	SHEET NO.

Rock Mass Rating (RMR)

- proposed by Bieniawski
- Ref: Intro. to Rock Mechanics, Goodman, R. E.

Index	Stage 4 Rock	Rating	Possible Points
Compressive Strength	~5000 psi (= 35 MPa)	7	15
RQD	48	8	20
Joint Spacing	~8 inches (0.2 m)	10	30
Joint Condition	Rough Surfaces	22	25
Water Conditions		4	10
		51	100

Water Conditions:

$$P/\sigma_v' = \frac{\text{Water Pressure in Joints}}{\text{Major Principle Stress}}$$

$$P/\sigma_v' = \frac{\gamma_{H_2O} \cdot Y}{\gamma_{Rock} \cdot Y} \cong \frac{\gamma_{H_2O}}{G_s \cdot \gamma_{H_2O}} = \frac{1}{G_s}$$

$$P/\sigma_v' = 1/2.6 = 0.38$$

"Fair Rock"

Rock Mass	RMR
Very Good	81-100
Good	61-80
Fair	41-60 ←
Poor	21-40
Very Poor	0-20

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAC	DATE: 3/92	SHEET: 1
	SUBJECT TITLE: RQD Values	CHECKED BY:	DATE:	CONTRACT NO.: ROCH4 DM-6

Boring	Run #	Core Depth Below Surface	Core Depth Below Rock	Run (Feet)	Recovery (%)	RQD (%)	RQD - 10 Ft Ave. Run×RQD	RQD - 10 Ft Ave. ΣRun	RQD - 10 Ft Ave. $\overline{RQD}$
81-33	1	10	5	4.0	95	28	112	—	—
	2	15	10	4.6	94	34	156	8.6	31 low
81-35	1	15	5	5.1	100	69	352	—	—
81-36	1	8	5	5.0	76	62	310	—	—
	2	12	10	1.4	100	50	70	6.4	59
89-252	1	16	4	5.0	80	43	215		
	2	21	9	5.0	90	62	310	10	53
	3	26	14	5.0	80	75	375		
	4	31	19	4.2	81	66	277	9.2	high 71
	5	35	23	1.3	100	38	49	10.5	67
89-261	1	20	5	1.7	76	24	41	—	—
	2	22	7	3.3	88	34	112	—	—
	3	25	10	3.8	100	50	190	—	—
	4	28	13	0.8	100	100	80	9.6	44
89-262	1	10	3	5.0	84	35	175	—	—
	2	15	8	5.1	100	55	281	10.1	45
	3	20	13	2.9	93	0	0	8.0	35
89-263	1	16	2	5.0	100	82	410	—	—
	2	21	7	3.5	91	43	151	8.5	66
	3	25	11	3.3	100	43	142	11.8	60
	4	28	14	2.1	100	57	120	8.9	46
				Σ = 77			Σ = 3928		

CENCS 23JAN92

US Army Corps of Engineers Saint Paul District	PROJECT TITLE: Bear Creek	COMPUTED BY: DAC	DATE: 3/92	SHEET: 2
	SUBJECT TITLE: RQD values	CHECKED BY:	DATE:	CONTRACT NO.: ROC #4 DM-6

Boring	Run #	Core Depth Below Surface	Core Depth Below Rock	Run (Feet)	Recovery (%)	RQD (%)	RQD - 10 Ft Ave Run×RQD	RQD - 10 Ft Ave ΣRun	RQD - 10 Ft Ave RQD
89-264	1	15	5	5.0	88	42	210	–	–
	2	20	10	4.9	100	75	368	9.9	58
	3	25	15	3.0	33	13	39	7.9	52 Median
92-295	1	14	0.5	1.7	100	0	0	–	–
	2	16	2.5	4.4	96	45	198	–	–
	3	20	6.5	3.6	97	47	169	9.7	38
	4	24	10.5	1.8	73	35	63	9.8	44
	5	26	12.5	5.0	95	72	360	–	–
	6	31	17.5	5.5	75	31	171	10.5	51 Median
92-296	1	11	1	2.7	90	0	0	–	–
	2	13	3	4.2	75	45	189	–	–
	3	17	7	4.6	90	54	248	11.5	38
	4	22	12	5.0	80	68	340	9.6	61
	5	27	17	1.8	90	22	40	11.4	55
	6	29	19	3.8	75	37	141	10.6	49

$\Sigma = 57.0$ $\qquad$ $\Sigma = 2536$

$$\text{Ave. RQD} = \frac{\Sigma(\text{Run} \times \text{RQD})}{\Sigma\ \text{Run}} = \frac{3928 + 2536}{77.1 + 57.0}$$

Ave RQD = 48.2

Median = 51.5

CENCS 23JAN92

APPENDIX D

STRUCTURAL ANALYSIS AND DESIGN

APPENDIX D

STRUCTURAL ANALYSIS AND DESIGN

TABLE OF CONTENTS

PARAGRAPH	DESCRIPTION	PAGE
1	INTRODUCTION	D-1
2	REFERENCES	D-1
	DESIGN CRITERIA	D-2
3	Reinforced Concrete Structures	D-2
4	Structural Steel	D-2
5	Steel Sheetpiling	D-2
6	Aluminum	D-2
7	Structural Timber	D-3
8	Unit Weights	D-3
9	Depth of Cover	D-3
10	Geotechnical Design Parameters	D-3
11	Design for Safety	D-3
12	Ice Loading	D-3
	DESIGN OF STRUCTURES	D-4
13	General	D-4
	PEDESTRIAN BRIDGES	D-4
14	Location	D-4
15-16	Design Loads and Cases	D-4
	DROP STRUCTURES AND OVERFLOW	D-4
17	Location	D-4
18	Design Loads	D-5
19-20	Uplift and Seepage	D-5
	RETAINING WALLS	D-5
21	Location	D-5
22-23	Design Loads	D-6
	UNDERPASSES	D-6
24-25	General	D-6
26-27	Design Loads	D-7
	CULVERT WITH FLAPGATES	
28	Location	D-7
29	Design Loads	D-7
30	BRIDGE SCOUR PROTECTION	D-7
31	WINGWALL EXTENSIONS	D-8

STRUCTURAL CALCULATIONS

DESCRIPTION	PAGE
ANALYSIS FOR PEDESTRIAN BRIDGES	D-9
DOWNSTREAM DROP STRUCTURE	D-23
UPSTREAM DROP STRUCTURE	D-54
RETAINING WALLS	D-104

APPENDIX D
STRUCTURAL ANALYSIS & DESIGN

INTRODUCTION

1. This appendix describes the methodology and assumptions used in the analysis and/or design of:

a. Retaining Walls
b. Pedestrian Bridge Foundations
c. Drop Structures
d. Underpasses
e. Bridge Scour Protection
f. Wingwall Extensions
g. Outlet Structures

REFERENCES

2. The applicable sections of the following references were used to formulate design criteria and to determine allowable stresses in the various structural components:

a. EM 1110-1-2101, Working Stresses for Structural Design (November 1963).

b. EM 1110-2-2103, Details of Reinforcement-Hydraulic Structures (May 1971).

c. EM 1110-2-2906, Design of Pile Structures and Foundations (Draft) (July 1969).

d. ETL 1110-2-256, Sliding Stability for Concrete Structures (June 1981).

e. ETL 1110-2-275, Concrete Removal Methods (July 1982).

f. ETL 1110-3-338, Wind and Snow Loads (February 1983).

g. EM 1110-2-2002, Evaluation and Repair of Concrete Structures (July 1986).

h. EM 1110-2-2000, Standard Practices for Concrete (September 1985).

i. EM 1110-2-2200, Gravity Dam Design (September, 1958).

j. EM 1110-2-2502, Retaining and Flood Walls (29 September 1989).

k. EM 1110-2-2102, Waterstops and Other Joint Materials (May 1983).

l. ETL 1110-2-312, Strength Design Criteria for Reinforced Concrete Hydraulic Structures (March 1988).

m. EM 1110-2-1612, Ice Engineering (October 1982).

n. EM 1110-2-XXXX, Strength Design for Reinforced Concrete Hydraulic Structures, Draft (January, 1990).

o. Steel Construction Manual (AISC Ninth Edition).

p. Building Code Requirements for Reinforced Concrete (ACI 318-89).

q. American Association of State Highway and Transportation Officials Standard Specifications for Highway Bridges 1989 as amended by 1990 and 1991.

r. Mn/DOT (Minnesota Department of Transportation) Bridge Design Manual.

s. Mn/DOT Bridge Details Manual.

DESIGN CRITERIA

REINFORCED CONCRETE STRUCTURES

3. The reinforced concrete retaining walls, drop structures, pedestrian bridge foundations, abutment wingwall extensions, bikeway retaining walls, bridge scour protection and outlet structures were designed in accordance with the principles of Load Factor Design. Ultimate concrete compressive strength (f'c) of 4,000 psi was used for design. Maximum design yield strength of reinforcing steel was limited to 48,000 psi in deformed billet steel bars of Grade 60 or better.

STRUCTURAL STEEL

4. Structural steel generally conformed to the requirements of ASTM A36 and A588. The trashrack and flap gates were designed in accordance with EM 1110-1-2101 using a basic working stress of 18,000 psi.

STEEL SHEETPILING

5. Steel sheetpiling shall conform to the requirements of ASTM A328. The maximum allowable stress shall conform to the requirements of EM 1110-2-2906 and EM 1110-1-2101.

ALUMINUM

6. Aluminum required for miscellaneous elements shall be 6061-T6. Working stresses used in the designs will be in accordance with EM 1110-1-2101.

STRUCTURAL TIMBER

7. The timber used shall be treated Douglas Fir Dense No. 1 Grade or better as designated by the Western Wood Products Associations.

UNIT WEIGHTS

8. The assumed design unit weights are as follows:

Concrete	150 P.C.F.
Steel	490 P.C.F.
Water	62.4 P.C.F.
Timber	40 P.C.F.
Insitu Bedrock	160 P.C.F.
Insitu Alluvium	
Moist	115 P.C.F.
Saturated	125 P.C.F.
Backfill	
Moist	120 P.C.F.
Saturated	125 P.C.F.

DEPTH OF COVER

9. Pedestrian bridge piers and abutments, wingwall extensions, retaining walls outside of the river channel, and the bikeway retaining walls were designed to be founded on soil with a minimum frost cover of 5'0" beneath the bedding layer. Riprap was not considered a frost protective material. Footings for piers in river channel were designed on soil with a minimum cover of 4 feet.

GEOTECHNICAL DESIGN PARAMETERS

10. The geotechnical design parameters used are: existing soil, backfill-internal angle of friction, 33^{o}, allowable bedrock bearing capacity, 12 t.s.f. Information on the development of these parameters is found in Appendix C.

DESIGN FOR SAFETY

11. All of the retaining walls, bridges, outlet structures and drop structures pose a threat to public safety because of their accessibility to the general public and their excessive heights. In designing for safety at these and other structures, consideration was given to developing features that will help prevent injuries to persons falling off the structures and will help prevent drownings. Practical solutions such as handrail and chain link fence will be implemented.

ICE LOADING

12. The piers for the Pedestrian bridges were designed for ice loads in accordance with EM 1110-2-1612. An ice thickness of 6 inches and a strength of 200 psi was used for dynamic loading.

DESIGN OF STRUCTURES

GENERAL

13. The proposed structures were designed for their intended use and were analyzed to determine their adequacy, shape, and stability at critical sections. Designs were completed in sufficient detail to permit the development of cost estimates. Sample calculations for the pedestrian bridges, drop structures, and retaining walls follow the text. Also, coordination with MnDOT because of one U.S. 14 bridge replacement is underway.

PEDESTRIAN BRIDGES

LOCATION

14. Three pedestrian/light vehicle bridges are to be constructed at Stations 40+15, 51+25, and 70+00.

DESIGN LOADS AND CASES

15. Substructures consisting of concrete piers and abutments for the bridges were designed. The substructure system for each of the three bridges consists of two piers and two abutments. Bridges at Stations 40+60 and 51+25 have similar total lengths of 195 feet, with mid-span lengths of 90 feet - 9 inch and end spans of 52 feet - 1 1/2 inch. The third bridge at Station 70+00 has a total length of 205 feet, with a mid-span length of 128 ft-4 inch and end spans of 33 feet - 4 inch. The bridge foundations were designed for the most critical of two cases, 1) using vertical, uplift, stream flow and ice load forces with no superstructure forces (construction case), or 2) using these same forces and including the superstructure dead and live load forces. The bridge spans are prefabricated and have end-bearing space requirements that effected the minimum pier and abutment widths.

16. Each bridge span was positioned perpendicular to the channel control line (skew angle = 0^{o}). The superstructure is a composite steel box girder bridge with a 10 foot wide timber deck. A 4 feet-6-inch height between bridge deck and top of side truss is maintained the entire length of each bridge. Design live load of 60 psf is in accordance with AASHTO specifications. Structural steel for the bridge will meet the requirements of ASTM a 572, grade 50.

DROP STRUCTURES AND OVERFLOW

LOCATION

17. The two drop structures will be constructed at Station 12+65 and 71+33. The upstream drop structure (Station 71+33) is comprised of three different sections: the drop structure, and the left and right

overflow embankments. The upstream weir of the drop structure is located at Station 71+65. The upstream drop structures is 140 feet wide: the left and right overflow embankments extend 245 feet and 570 feet to the left and right respectively, of the drop structure. Concrete training walls separate the drop structure from the overflow embankments. Concrete abutment walls, with a 5-foot radius, and concrete breast walls are located on the upstream end of the drop structure. Concrete wingwalls, flaring at a rate of 1 - horizontal to 1.5 - longitudinal, are located on the downstream end. The downstream drop structure (Station 12+65) is similiar but has a width of 75 feet and no downstream wingwalls. The weir is located at Station 13+03. The concrete abutment walls are located on the upstream end and curve to meet the concrete breast walls at Station 13+08. The breast walls are 36 feet in length.

DESIGN LOADS

18. Soil parameters used were previously discussed in paragraph 10. Soil lateral forces on the land side were computed using a S.M.F. of 2/3 applied to the angle of internal friction. Critical load cases were determined for sections of the drop structure, side walls and retaining walls. Load factors of 1.9 for dead and live loads were used in the structural design of the components.

UPLIFT AND SEEPAGE

19. Upstream cutoffs in the form of 10 foot long sheet piles were provided for the upstream drop structure and extend 10 feet into the upstream wingwalls. The two sides and the downstream sill wall have a 4 foot deep unreinforced concrete cutoff wall. The downstream cutoff also has a coarse drainage fill with a continuous 6 inch diameter perforated PVC pipe with weepholes to help relieve uplift pressures. The downstream drop structure has an unreinforced concrete cutoff around the entire perimeter. It is 2-feet-6-inch deep and extends into the bedrock. The entire downstream drop structure is built on top of a 12-inch coarse drainage fill with a continuous 6" perforated PVC pipe behind the sill wall. The PVC pipe has weepholes spaced at 10-feet on center.

20. The uplift pressures were determined by the geotechnical section. The stability of the drop structures were obtained by making the base slab thicker, thereby increasing the dead weight. The base of the retaining wingwalls were increased in width to provide the necessary stability.

RETAINING WALLS

LOCATION

21. The concrete retaining walls are in four locations. The first retaining wall is an extension of the downstream left bank wingwall for the 4th St. SE bridge. It is needed to support an existing driveway/sidewalk area and is about 100 feet long, from Station 5+05 to

location is at the 6th St. SE bridge. Four retaining walls on each corner of the bridge are needed, ranging in length from 21 feet on the downstream right bank to 200 feet on the upstream left bank. The third location for retaining walls is on both banks between the U.S. 14 bridges. The walls are 38 feet in length, from Station 62+00 to 62+38. The fourth location is for each of the pedestrian underpasses.

DESIGN LOADS

22. A concrete retaining wall analysis spreadsheet based on EM 1110-2-2502 was developed to analyze the retaining walls in Stage 2A and was used in this stage as well. The retaining walls were analyzed using loading conditions R1 and R2 from the manual. The spreadsheet conducts a seepage analysis by line-of-creep method to calculate water forces on the wall. The soil parameters used are discussed in paragraph 10.

23. For consideration of live loads on walls next to roads, parking lots and sidewalks, a uniform 2 foot surcharge was included in the analysis. Design criteria for the retaining walls was recommended by NCD. The criteria submitted by NCD and adopted for this project is shown below:

Load Case: R1

Soil Strength Mobilization Factor:	0.667
Driving Side Soil Pressure:	Active with SMF
Resisting Side Soil Pressure:	1/2 Passive
Minimum Sliding Safety Factor:	1.5
Min. Percent of Base in Compression:	100
Minimum Bearing Factor of Safety:	2.5
Concrete Design Live Load Factor:	1.7

Load Case: R2

Soil Strength Mobilization Factor	0.75
Driving Side Soil Pressure:	Active with SMF
Resisting Side Soil Pressure:	1/2 Passive
Minimum Sliding Safety Factor:	1.33
Min. Percent of Base in Compression:	75
Minimum Bearing Factor of Safety:	2.0
Concrete Design Live Load Factor:	1.3

UNDERPASSES

GENERAL

24. The underpasses are located on the right banks at 4th St. SE, 6th St. SE, and U.S. 14 bridges. All three underpasses were designed for bicycle and pedestrian use. The underpass at 4th St. SE bridge requires a retaining wall on the riverward side of the path and wingwall extensions both upstream and downstream of the abutments.

25. The elevation of the base of the retaining walls at 4th St. SE and U.S. 14 bridges are lower than the base of the existing bridge abutment footings (2.4 feet and 4.8 feet, respectively). The toe of these retainings walls is located as close as possible to the existing bridge abutment to provide for a suitable path width and to have the largest bridge hydraulic opening.

DESIGN LOADS

26. The critical case for the design of the concrete retaining walls supporting the path for the bicycle underpasses occurs after a flood. The water level on the land side of the wall is at the top of the wall with the river water receded. Floods are typically of short duration, and the possibility exists that flood waters could overtop the walkaway and then recede quickly.

27. A soil mobilization factor of 2/3 was applied to the landside soils for sliding and overturning. Load factors of 1.5 for dead loads and 1.9 for live loads were used for design of all reinforcing steel.

CULVERT WITH FLAP GATES

LOCATION

28. The 48 inch diameter reinforced concrete pipe culvert with flap gate is located at Station 18+50L of the left tie back levee. The tie back levee is upstream of the upstream drop structure.

DESIGN LOADS

29. The culvert consists of a flared concrete intake with a trash rack connected to a 48" RCP that runs through the levee. It outlets through a flap gate to a flared concrete headwall. The structure was checked for flotation stability in accordance with EM 1110-2-307. The load factors of 1.5 for dead loads and 1.9 for live loads were used for design of all reinforcing steel.

BRIDGE SCOUR PROTECTION

30. Bridge scour protection is provided where the new channel goes below the existing piers or abutments. At the 4th St. SE bridge the left abutment is protected with a block of concrete 4-feet-6-inch deep and 4 feet wide. The right abutment is protected by the retaining wall of the underpass. At the 6th St. SE bridge the right and left abutment are protected by a concrete slope. At the U.S. 14 bridges the left abutment and two piers are protected by a concrete block 4 to 6 feet deep and 4 to 5 feet wide. The right abutment is protected by the retaining wall of the underpass. Concrete expansion material will be placed between the scour protection concrete and the existing bridge piers, abutments and retaining walls for the bicycle underpasses.

WINGWALL EXTENSIONS

31. The abutment wingwall extensions on the 4th St. SE and U.S. 14 bridges are located in the road embankment on existing soil. The walls were designed for dead load plus saturated backfill without any live load surcharge. The backfill slopes up from the wall which was considered in the wall stability and design. These walls, as well as the existing bridge abutments, will be isolated from the concrete bike path pavement with expansion joint material.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 FEB 92	PAGE 1 OF	FILE NUMBER PHASE 4
NAME OF OFFICE ED-D		COMPUTATION	
SUBJECT PEDESTRIAN BRIDGES		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

ANALYSIS FOR PEDESTRIAN BRIDGES

- TYPE OF SUPERSTRUCTURE: PREFAB - TOWN & COUNTRY OR EQU
- LOCATIONS: STA. 40+60.00
  STA. 51+25.00
  STA. 70+00.00
- DESIGN PARAMETERS: $f_c' = 4000$ psi
  $f_y = 48\,000$ psi (GRADE 60 STEEL
- DESIGN FLOOD LEVELS (DHW): STA 40+60.00 EL. 996.90
  STA 51+25.00 EL. 998.90
  STA 70+00.00 EL. 1003.20
- CHANNEL INVERT: STA 40+60.00 EL. 985.20 (ROCK
  STA 51+25.00 EL. 987.50 (18"+9
  STA 70+00.00 EL. 991.20 (21"+9
  -19.5
- FOOTING ELEVATIONS: STA 40+60.00 EL. 979.00
  STA 51+25.00 EL. 981.00
  STA 70+00.00 EL. 985.00
- PIER TOP OF WALKWAY: STA 40+60.00 EL. 1001.5
  STA 51+25.00 EL. 1003.5
  STA 70+00.00 EL. 1006.8
- RIPRAP THICKNESS: STA 40+60.00 ROCK
  STA 51+25.00 (18"+9")
  STA 70+00.00 (21"+9")
- BACKFILL SOIL PROPERTIES: $\gamma_{SAT} = 125$ pcf $c = 0$
  $\gamma_{moist} = 120$ pcf $\phi = 33°$
- LOADING: UL = .060 psf
  CL = 10K

BRIDGE DL = .500 K/ft (PREFAB)

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 FEB 92	PAGE 2 OF	FILE NUMBER PHASE 4

NAME OF OFFICE ED-D	COMPUTATION
SUBJECT PEDESTRIAN BRIDGES	SOURCE DATA

COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY

ABUTMENT FOOTING:

LOAD / FOOT :

DL FOOTING : $.150(9.5 \times 1.5 + 1.5 \times 8.5) = 4.05$ K/foot

DL EARTH : $.125(2.5 \times 5.5 + 5.5 \times 8.5) = 7.56$ K/foot

DL BRIDGE $.55$

LL : $.10 \times .060 \times \frac{52.12}{2} \left(\times \frac{10000}{23}\right) \frac{1}{23} = .69$ K/ft $(.44)$

TOTAL : $V = \underline{12.80}$ K/ft

PRESSURE : $p = \frac{12.80}{9.5} \pm \frac{1.2 \times 1.756}{9.5^2}$

$= 1.35 \pm .15 = +1.20$ Ksf

$+1.50$ Ksf $\therefore$ OK

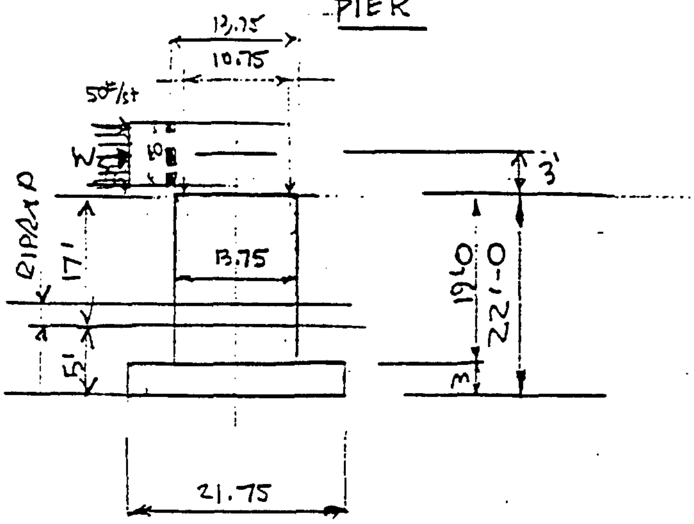
AS PER PREVIOUS DESIGNS ABUTMENT IS SUFFICIENT.

FOR ADDED INFO SEE D-17 through D-21.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 FEB 92	PAGE 3 OF	FILE NUMBER PHASE 4
NAME OF OFFICE ED-D		COMPUTATION	
SUBJECT PEDESTRIAN BRIDGES		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

BRIDGES : STA 40+60.00 & 51+25

PIER



VERTICAL LOADS:

DL: BRIDGE $R = \frac{52.12+90.75}{2} \times .500 = \underline{35.7^K}$

PIER : $P = .150\,(3\times12\times21.75 + 3\times10.75\times19 + 1.5^2\times3.14\times19)$

$= .150\,(783 + 612.8 + 136.8) = \underline{230}^K$

LL: BRIDGE $L = \frac{\overbrace{52.12+90.75}^{72'}}{2} \times 10 \times .060 = \underline{42.9^K}$

HORIZONTAL LOADS:

1. WIND ON SUPERSTRUCTURE (.050 k/ft)

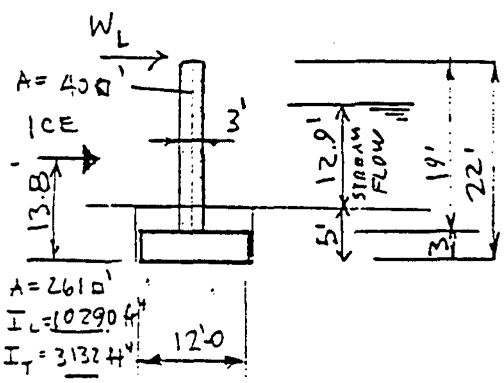
$W_S = .050 \times 72' \times 2.5 = \underline{6.25^K}$

$W_L = .012 \times 72 \times 2.5 = \underline{2.15^K}$

$W_S + W_L$ ACTS 3'-0 ABOVE PIER CAP

2. WIND ON SUBSTRUCTURE (.040 lbs/ft)

$W_P = .040 \times 3 \times 17 = \underline{2.04^K}$



3. ICE LOAD (AASHTO 3.18.2.2)

$F_L = C_p\, p\, t\, w$

$= 1.00 \times .20^k/_{''} \times 6'' \times 36'' = \underline{43.2}^K$

$F_T = 15\%\ F_L$ AS PER COE MANUAL

$= .15 \times 43.2 = \underline{6.5}^K$

ACTING AT 5YR FLOOD ELEVATION

STA 40+60.00 EL 992.3 - 977.0

STA 51+25.00 EL 994.8 - 981.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 FEB 92	PAGE 4 OF	FILE NUMBER PHASE 4
NAME OF OFFICE ED-D	COMPUTATION		
SUBJECT PEDESTRIAN BRIDGES	SOURCE DATA		
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

4. STREAM CURRENT:

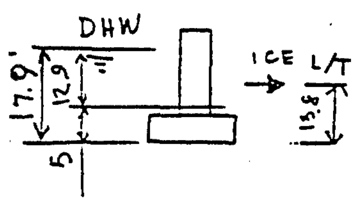
$P = KV^2$ (AASHTO 3.18.1)

$P = \frac{2}{3} \times 6^2 = \underline{24\ psf}$

STABILITY ANALYSIS:

CASE I: NO SUPERSTRUCTURE

FORCES:



VERTICAL LOADS: $V = \underline{230^K}$

UPLIFT: $U = .0625 \times [17.9 \times 261 - 14.9 \times (261-40)]$
$= .0625 [4672 - 3292] = \underline{86.2^K}$

STREAM FLOW: $H_{FL} = .024 \times 3 \times 12.9 = \underline{.95^K}$

ICE LOAD: $F_L = \underline{43.2^K}$ (Reduced Uplift) $V = \underline{66.5^K}$

$F_T = \underline{6.5^K}$

STRESS - PRESSURE: .55

STREAM FLOW: $P_{FL} = \frac{230-86.2}{261} \pm \frac{.95 \times (5+6.45) \times \frac{21.75}{2}}{10290} = \underline{.55}$

ICE PRESSURE: $P_{ICE} = .55 \pm \frac{13.8 \times 43.2 \times \frac{21.75}{2}}{10290} \pm \frac{13.8 \times 6.5 \times \frac{12}{2}}{3132}$

$= .62 \pm .63 \pm .17 = \underline{1.43\ ksf}$, $\underline{-.18\ ksf}$

SLIDING: $S = (230-66.5) \times .577 = \underline{94.3^K} > \underline{43.2}$ ∴ ok

CASE 2: INCLUDE SUPERSTRUCTURE (DL + LL)

2.a. NO STREAM FLOW

$P = \frac{35.7 + 230 + 42.9}{261} = \underline{1.18\ ksf}$

2.b. INCLUDE ICE LOAD

$P_{ICE} = \frac{230 - 66.5 + 78.6}{261} \pm .63 \pm .17 = \underline{1.73\ ksf}$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 FEB 92	PAGE 5 OF	FILE NUMBER PHASE 4
NAME OF OFFICE ED-D		COMPUTATION	
SUBJECT PEDESTRIAN BRIDGES		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

2.C. INCLUDE WIND + ICE + DL (NO LL)

$$P = \frac{230+357.7-66.5}{261} \pm \frac{6.25 \times 22 \times \frac{21.75}{2}}{10290} \pm \frac{2.15 \times 22 \times \frac{12}{2}}{3132} \pm .63 \pm .17$$

$$= 1.75 \pm .15 \pm .10 \pm .80 = \begin{cases} +1.80 \text{ ksf} \\ -.30 \text{ ksf} \end{cases}$$

SLIDING: $S = (230+357.7-66.5) \times .577 = \underline{\underline{114.94^K}}$

$H_{ICE+W} = 43.2^K + 6.25^K = \underline{\underline{59.45^K}}$

$H_{ICE+W} = 6.5 + 2.15 = \underline{\underline{8.65^K}}$

$\Sigma H = \sqrt{59.45^2 + 8.65^2} = \underline{\underline{60.12^K}}$

OVERTURNING IS NOT OF CONCERN.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 FEB 92	PAGE 6 OF	FILE NUMBER PHASE 4
NAME OF OFFICE E0-D	COMPUTATION		
SUBJECT PEDESTRIAN BRIDGES	SOURCE DATA		
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

BRIDGE STA.: 70+00.00

THE LOADING DUE TO VERTICAL DL + LL VARIES FROM PREVIOUS TWO BRIDGES, AN INCREASE IN VERTICAL LOAD WILL NOT ADVERSELY AFFECT THE CHOSEN PIER CONFIGURATION.

VERTICAL LOAD:

DL BRIDGE : $B = \frac{\overbrace{33.33 + 128.33}^{80.83}}{2} \times .500 = \underline{40.4^k}$

See page 3: ⇒ DL PIER : $P = \underline{230^K}$

LL : $L = 80.8 \times .060 = \underline{48.5^k}$

HORIZONTAL LOADS:

1. WIND ON SUPERSTRUCTURE (.050 k/sf)

$W_S = .050 \times 80.83 \times 2.5 = \underline{10.1^K}$

$W_L = .012 \times 80.83 \times 2.5 = \underline{2.5^K}$

$W_S + W_L$ ACTS 3'-0 ABOVE PIER CAP

2. WIND ON SUBSTRUCTURE

$W_P = \underline{2.04^K}$

3. ICE LOAD

See pg 3 ⇒ $F_L = 43.2^K$

$F_T = 6.5^K$

ACTING AT 5YR FLOOD ELEVATION STA 70+00.00

4. STREAM CURRENT

$P = \underline{24}$ psf

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 FEB 92	PAGE 7 OF	FILE NUMBER PHASE 4
NAME OF OFFICE ED-D	COMPUTATION		
SUBJECT PEDESTRIAN BRIDGES	SOURCE DATA		
COMPUTED BY BBS	CHECKED BY DMT	APPROVED BY	

SUMMARY STATEMENT:

LOADS AND REACTIONS COMPARE FAVORABLY WITH PREVIOUSLY DETERMINED LOADS FOR PEDESTRIAN BRIDGES AT STA. 40+60.0 & 51+25.00. NO FURTHER COMPUTATIONS ARE REQUIRED OR WILL BE PERFORMED.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 JAN 92	PAGE 1 OF	FILE NUMBER ROCHESTER-PHASE 4
NAME OF OFFICE ED-D		COMPUTATION STRUCTURES	
SUBJECT RETAINING WALLS/BRIDGE ABUTMENTS		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

POS 1 : RETAINING WALL
BRIDGE ABUTMENTS

GEOTECH INFO: SOIL PARAMETER
(CENCS-ED) General Backfill:
4 NOV 1991

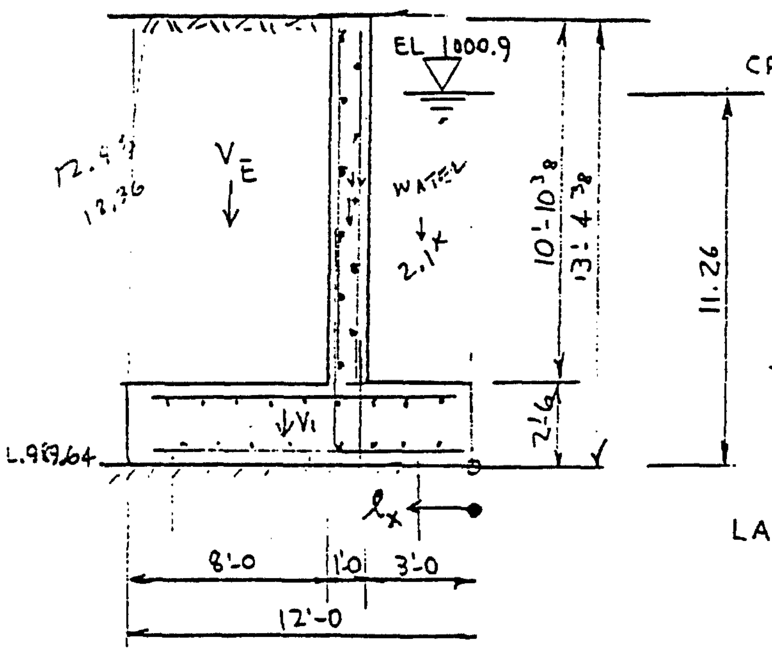
$\gamma_m = 115\,pcf$; $\gamma_{sat} = 125\,pcf$; $\phi = 33°$

$tg\phi = .6494$

SMF $= \frac{2}{3}$ $\quad \beta = 0$

$tg\,\phi_D = \frac{2}{3}\,tg\,\phi = .4329$

$\longrightarrow \phi_D = 23.41°$



CRITICAL SLIP ANGLE α :

$C_1 = 2 \times tg\,\phi_D = \underline{.866}$

$C_2 = 1$

$\alpha = tg^{-1}\,\dfrac{C_1 + \sqrt{C_1^2 + 4C_2}}{2}$

$= tg^{-1}\,\dfrac{.866 + \sqrt{.866^2 + 4}}{2} = \underline{\underline{tg^{-1}\,1.5227}}$

$\rightarrow 56.706$ $\quad \sin\alpha = .8359$

$\cos\alpha = .5489$

$tg\,\alpha = 1.5227$

$ct\,\alpha = .6567$

LATERAL EARTHPRESSURE COEFFICIENT

$K = \dfrac{1 - tg\,\phi_D\,ct\,\alpha}{1 + tg\,\phi_D\,tg\,\alpha} = \dfrac{1 - .4329 \times .6567}{1 + .4329 \times 1.5227} =$

$= \dfrac{1 - .2843}{1 + .6592} = \underline{\underline{.43}}$

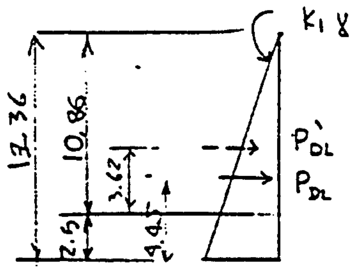
$K_1 = K\,\dfrac{tg\,\alpha}{tg\,\alpha - tg\,\beta} = \underline{\underline{.43}}$

$K_b = K\left[1 + \left(\dfrac{tg\,\alpha}{tg\,\alpha - tg\,\beta} - 1\right)\dfrac{\gamma_m}{\gamma_b}\right] = \underline{\underline{.43}}$

$K_v = K\,tg\,\alpha = \underline{\underline{.65}}$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 JAN 92	PAGE 2 OF	FILE NUMBER
NAME OF OFFICE ED-D		COMPUTATION STRUCTURES	
SUBJECT RETAINING WALLS/BRDGE ABOTMENTS		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

LATERAL FORCES

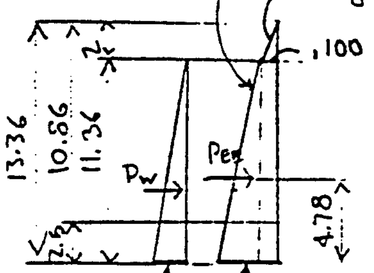


CASE 1: DL - EARTH

$P_{DL} = .050 \times \frac{13.36^2}{2} = \underline{4.46^K}$

$P'_{DL} = .050 \times \frac{10.86^2}{2} = \underline{2.95^K}$

CASE 2: DL + HYDROSTATIC PRESSURE



ADJUSTED FOR DRAW DOWN PAGE 3: .53 KSF

EARTH LOAD:

$.100 \times \frac{2}{2} = .100 \times (11.36 + \frac{2}{3}) = 1.200$

$.100 \times 11.36 = 1.136 \times 11.36/2 = 6.453$

$.310 \times \frac{11.36}{2} = 1.761 \times 11.36/3 = \underline{6.668}$

$P_{EE} = \underline{2.997^K}$ $M_{EE} = \underline{14.320^{'K}}$

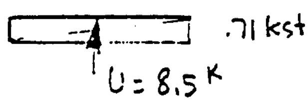
$y = \frac{14.320}{2.997} = \underline{4.78'}$

$P_w = .71 \times \frac{11.36}{2} = \underline{4.03^K}$ ARM $= \frac{11.36}{3} = 3.79'$

$P_w = .53 \times \frac{11.36}{2} = \underline{3.01^K}$ ⇐ USE FOR SLIDING

CASE 3: BUOYANCY

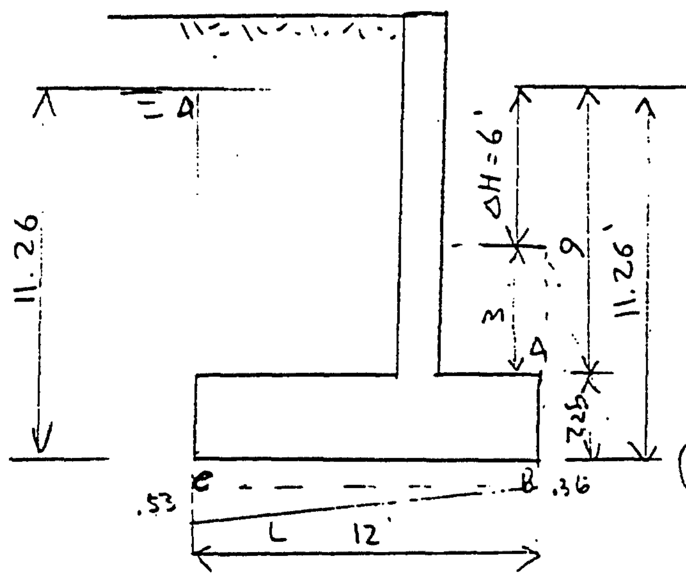
3.A. UNIFORM UPLIFT; $U_a = .71$ ksf $\times 12 = \underline{8.5^K}$



ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 JAN 92	PAGE 3 OF	FILE NUMBER
NAME OF OFFICE ED-D		COMPUTATION STRUCTURES	
SUBJECT RETAINING WALLS/BRIDGE ABUTMENTS		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

3.B. BUOYANCY FOR TRIANGULAR (TRAPEZOID) LOAD (DRAW DOWN):

$L_{AB} = 2.24$
$L_{BC} = 12.00$
$L_{CD} = 11.26$
$\Sigma L = 25.50$



$U_D = 0$

$U_C = \left[11.26 - \frac{6 \times 11.26}{25.50}\right] .0625$
$= \underline{.53^{KSF}}$

$U_B = \left[11.26 - \frac{6 \times 23.26}{25.5}\right] .0625$
$= \underline{.36^{KSF}}$

$U = .36 \times 12 + .17 \times \frac{12}{2} = 4.32 + 1.02 = \underline{5.34^K}$

$+M_D = 4.32 \times 6 + 1.02 \cdot \frac{2}{3} 12 = 25.92 + 8.16 = \underline{34.08^K}$

$\leftarrow H = .36 \times \frac{2.25+3}{2} = .95^K$

$M_H = .95 \times \frac{5.25}{3} = \underline{1.66^{FK}}$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 JAN 92	PAGE 4 OF	FILE NUMBER
NAME OF OFFICE ED-D	COMPUTATION STRUCTURES		
SUBJECT RETAINING WALLS/BRIDGE ABUTMENTS	SOURCE DATA		
COMPUTED BY BES	CHECKED BY DMT	APPROVED BY	

CASE 4: VERTICAL DL (SATURATED GROUND)

LOCI	WEIGHT	W	ℓ_x	$W \times \ell_x$
V_1	.150x2.5x12.0	4.5	12/2	- 27.0
V_2	.150x10.67x1.0	1.63	$(3+\frac{1}{2})$	- 5.71
V_E	.125x10.87x8.0	10.87	$(4+\frac{8}{2})$	- 86.96
Σ		16.97^k		-119.67^{+k}
		$\ell_x = \frac{-119.67}{16.97} = -7.05$		

PRESSURE CHECK

R1: DL ONLY (CASE 1):

$$\ell_R = \frac{4.46 \times 4.45 - 119.67}{16.97} = -5.88' \qquad \ell = 6 - 5.88 = .12'$$

$$p = \frac{16.97}{12} \times \left(1 \pm \frac{.12 \times 6}{12}\right) = \left.\begin{matrix} +1.50 \text{ ksf} \\ +1.33 \text{ ksf} \end{matrix}\right\}$$

AREA IS 100% IN COMPRESSION

R2: DL + HYDROSTATIC PRESSURE (CHANNEL DRAW DOWN)

$$\ell_R = \frac{14.32 + 4.03 \times 3.79 + 34.08 - 119.67 - 1.66}{16.97 - 5.34}$$

$$= \frac{14.320 + 15.252 + 34.08 - 118.0}{11.63} = -4.67' \qquad \ell = 6 - 4.67 = 1.33'$$

$$p = \frac{11.63}{12} \left(1 \pm \frac{1.33 \times 6}{12}\right) = \left.\begin{matrix} +1.61 \text{ ksf} \\ +.32 \text{ ksf} \end{matrix}\right\}$$

(CHANNEL FULL FLOW)

$$\ell_R = \frac{14.320 + 8.5 \times \frac{12}{2} - 119.67}{16.97 - 8.5} = -\frac{54.35}{8.47} = -6.42'$$

$$p = \frac{8.47}{12} \left(1 \pm \frac{.42 \times 6}{12}\right) = \left.\begin{matrix} +.85 \text{ ksf} \\ +.42 \text{ ksf} \end{matrix}\right\}$$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 JAN 92	PAGE 5 OF	FILE NUMBER
NAME OF OFFICE ED-D		COMPUTATION STRUCTURES	
SUBJECT RETAINING WALLS/BRDGE ABUT.		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

SLIDING STABILITY:

$$T = \frac{N' \tan\phi + CL}{FS}$$

R_1: SF = 1.5

$$T_E = 4.46 < \frac{16.97 \times .6494}{1.5} = \underline{7.34^K}$$

R_2: SF = 1.33

$$T_D = 2.997 + 3.01 - .95 = 5.00^K$$

$$T_D = \underline{2.997}^K$$

$$T_D = 5.00 < \frac{11.63 \times .6494}{1.33} = \underline{5.67^K} \quad \therefore ok$$

$$T_D = 2.997 < \frac{9.15 \times .6494}{1.33} = \underline{\underline{4.47}}^K \quad \therefore ok$$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 JAN 92	PAGE C OF	FILE NUMBER
NAME OF OFFICE ED-D		COMPUTATION	
SUBJECT RETAINING WALLS/BRDGE ABUTMENTS		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

BEARING CAPACITY:

$\varphi = 33°$: TABLE 5-1 : $N_c = 38.64$ $B = 12'$-0

$N_q = 26.09$

$N_\gamma = 26.17$

CASE R1 : DL ONLY F.S.=3.0

DL : $\Sigma H = \underline{4.46^k}$ $M_H = 4.46 \times 4.45 = \underline{19.85}^{+k}$

$N' = \Sigma V = \underline{16.97^k}$ $M_V = -\underline{119.67}^{+k}$

$\bar{X}_R = \frac{-119.67 + 19.85}{16.97} = \underline{5.88'}$

$\delta = tg^{-1}\left(\frac{\Sigma H}{\Sigma V}\right) = tg^{-1}\left(\frac{4.46}{16.97}\right) = \underline{14.73°}$

$e = \frac{B}{2} - \bar{X}_R = \frac{12}{2} - 5.88 = \underline{.12'}$

$\bar{B} = B - 2e = 12 - 2 \times .12 = \underline{11.76'}$

$\gamma_v' = \underline{.125}$

$D = 1 \rightarrow q_0 = 1 \times .125 = \underline{.125}$

$$Q = \bar{B}\left[(\xi_{cd}\xi_{ci}\xi_{ct}\xi_{cg}\, c\, N_c) + (\xi_{qd}\xi_{qi}\xi_{qt}\xi_{qg}\, q_0 N_q) + \frac{1}{2}(\xi_{\gamma d}\xi_{\gamma i}\xi_{\gamma t}\xi_{\gamma g}\, \bar{B}\gamma_v' N_\gamma)\right]$$

$c = 0$

$\xi_{qd} = \xi_{\gamma d} = 1 + .1\left(\frac{D}{B}\right) tg\,(45 + \frac{\phi}{2}) =$

$= 1 + .1\left(\frac{1}{11.76}\right) tg\,(45 + \frac{33}{2}) = \underline{1}$

$\beta = tg^{-1}\left(\frac{1}{0}\right) = 0$

$\xi_{qi} = (1 - \frac{\delta}{90})^2 = (1 - \frac{14.73}{90})^2 = \underline{.70}$

$\xi_{\gamma i} = (1 - \frac{\delta}{\phi})^2 = (1 - \frac{14.73}{33})^2 = \underline{.31}$

$\xi_{qg} = \xi_{\gamma g} = [1 - tg\beta]^2 = \underline{1}$ $\xi_{qt} = \xi_{\gamma t} = \underline{1}$

$$Q = 11.76\left[(\nearrow^{0}) + (1.00)(.70)(1.0)(1.0)(.125)(26.09) + \frac{1}{2}(1.00)(.31)(1)(1)(11.76)(.125)(26.17)\right]$$

$= 11.76\left[\overset{2.28}{5.96}\right] = \underline{96.9^k}$

$F.S. = \frac{96.9}{16.97} = \underline{5.7} > 3.0$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 JAN 92	PAGE 7 OF	FILE NUMBER
NAME OF OFFICE ED-D		COMPUTATION	
SUBJECT RETAINING WALLS/BRIDGE ABUTMENTS		SOURCE DATA	
COMPUTED BY BGS	CHECKED BY DMT	APPROVED BY	

CASE R2 : DL + WATER F.S. = 2.0

$\Sigma H = P_{EE} + P_w - H = 2.997 + 3.01 - .95 = \underline{5.06^K}$

$M_H = M_{EE} + M_w - M_H = 14.32 + 3.01 \times 4.78 - 1.66 = \underline{27.05^{+K}}$

$N' = \Sigma V = \Sigma W_i - U_b = 16.97 - 5.34 = \underline{11.63^K}$

$M_V = +M_W - M_b = -119.67 + 34.08 = \underline{-85.59^{+K}}$

$\bar{X}_R = \frac{-85.59 + 27.05}{11.63} = \underline{5.03'}$

$\delta = tg^{-1}\left(\frac{\Sigma H}{N'}\right) = \left(tg^{-1} \frac{5.06}{11.63}\right) = \underline{23.51°}$

$e = \frac{B}{2} - \bar{X}_R = 6 - 5.03 = \underline{.97'}$

$\bar{B} = B - 2e = 12 - 2 \times .97 = \underline{10.06'}$

$\gamma'_0 = .125 - .0625 = \underline{.0625}$

$D = 1 \rightarrow q_0 = \underline{.0625}$

C = 0

$\beta = 0$

$Q = \bar{B}[(\varnothing) + (\xi_{qd}\xi_{qi}\xi_{qt}\xi_{qg}\, q_0 N_q) + \frac{1}{2}(\xi_{\gamma d}\xi_{\gamma i}\xi_{\gamma t}\xi_{\gamma g}\, \bar{B}\gamma'_0 N_\gamma)$

$\xi_{qd} = \xi_{\gamma d} = 1 + .1\left(\frac{D}{\bar{B}}\right) tg\left(45 + \frac{\phi}{2}\right) =$

$= 1 + .1\left(\frac{1}{10.06}\right) tg\left(45 + \frac{33}{2}\right) = \underline{1}$

$\xi_{qi} = \left(1 - \frac{\delta}{90}\right)^2 = \left(1 - \frac{23.51}{90}\right)^2 = \underline{.55}$

$\xi_{\gamma i} = \left(1 - \frac{\delta}{\phi}\right)^2 = \left(1 - \frac{23.51}{33}\right)^2 = \underline{.08}$

$\xi_{qg} = \xi_{\gamma g} = (1 - tg\beta)^2 = \underline{1}; \quad \xi_{qt} = \xi_{\gamma t} = \underline{1}$

$Q = 10.06\,[(\varnothing) + (1)(.55)(1)(1)(.0625)(26.09) + \frac{1}{2}(1)(.31)(1)(1)(10.06)(.0625)(26.\ldots$

$= 10.06\,[\,.897 + 2.55\,] = \underline{34.68^K}$

$F.S. = \frac{34.68}{N'} = \frac{34.68}{11.63} = \underline{\underline{2.98^K}} > 2.0$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 Oct '91	PAGE 1 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

The downstream drop structure has been moved downstream from Sta. 15+00 (GDM Location) to Sta. 12+65-13+00. The basic shape remains about the same as the GDM (see plate 53). It also remains on rock.

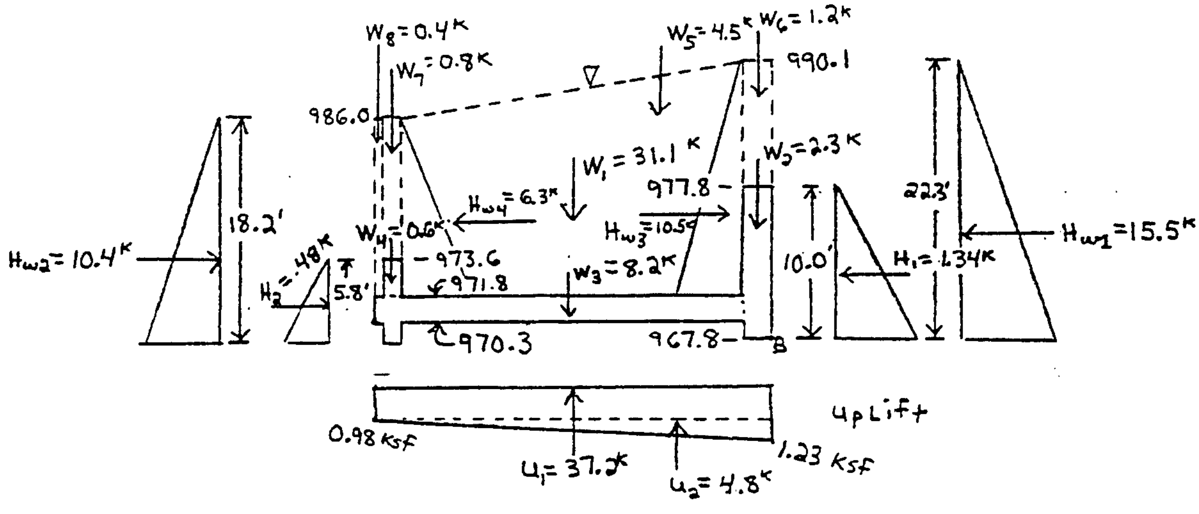
Assumptions:

f'_c = 4,000 psi
f_y = 48,000 psi (EM 1110-2-2502, para. 9-8, e, 2)
γ_{sat} = 125 lb/ft³
$\gamma_{sub.}$ = 62.5 lb/ft³
γ_{moist} = 120 lb/ft³
γ_{water} = 62.5 lb/ft³
c = 0 (cohesion)
ϕ = 26° between conc. & soil (for sliding)
= 33° " conc. & rock
= 33° " soil & soil

backfill (see Geo-Tech Memorandum 10-21-91)

Forces on the wall:

A. Look at Section A-A (U/S - D/S section)
(Unusual Loading Condition ⇒ Design water Surface Elevations)

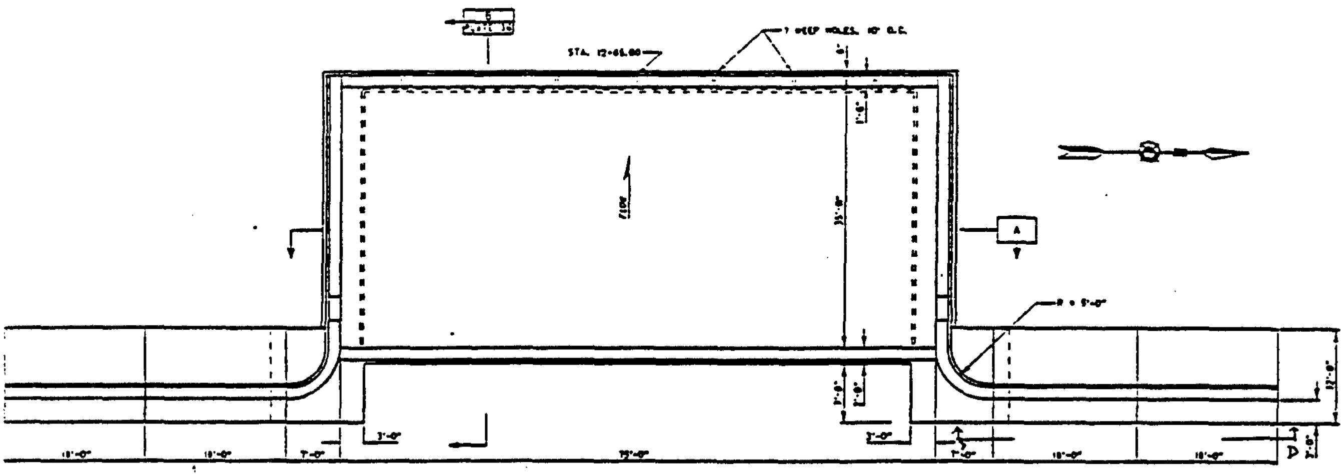


Bedrock:
ϕ = 0
c = 50 psi = 7.2 ksf
γ = 160 pcf (unit wt.)
Allowable bearing capacity on bedrock = 12 tsf (167 psi)

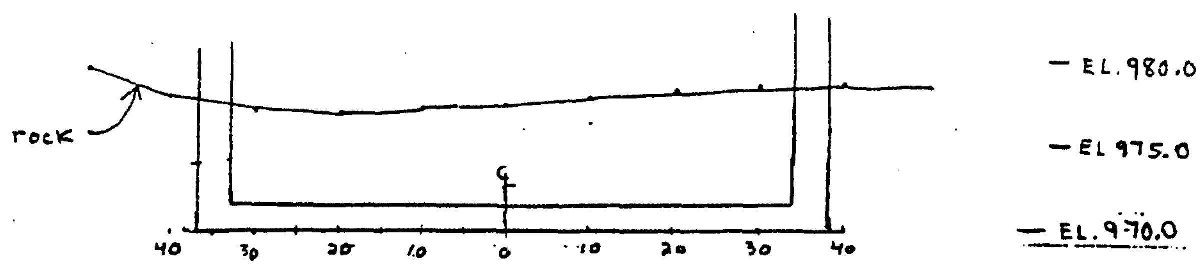
InSitu Soils:
ϕ = 26° between conc. & soil (sliding)
= 33° " conc. & rock
= 33° " soil & soil
c = 0
γ_{sat} = 125 pcf
γ_{moist} = 115 pcf

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 Oct '91	PAGE 2 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Avg.	50'	40'	30'	20'	10'	0	10'	20'	30'	40'	50'	Dist. from ℄
978.0	979.5	978.0	977.1	977.0	977.3	977.5	978.0	978.3	978.6	978.7	978.5	Rock Elev.

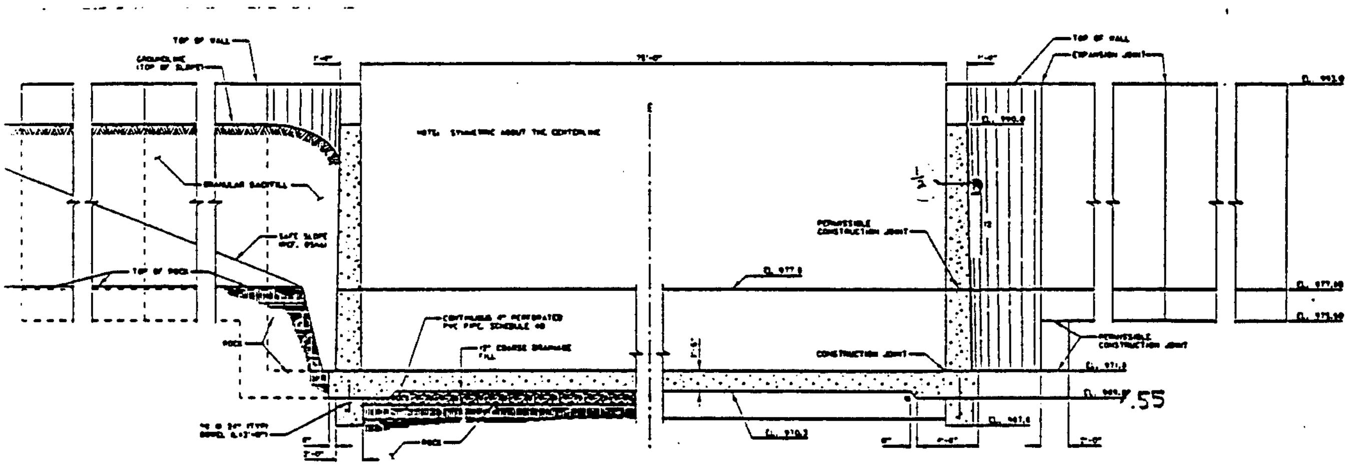


PLAN
DROP STRUCTURE
SCALE: 1/8" = 1'-0"



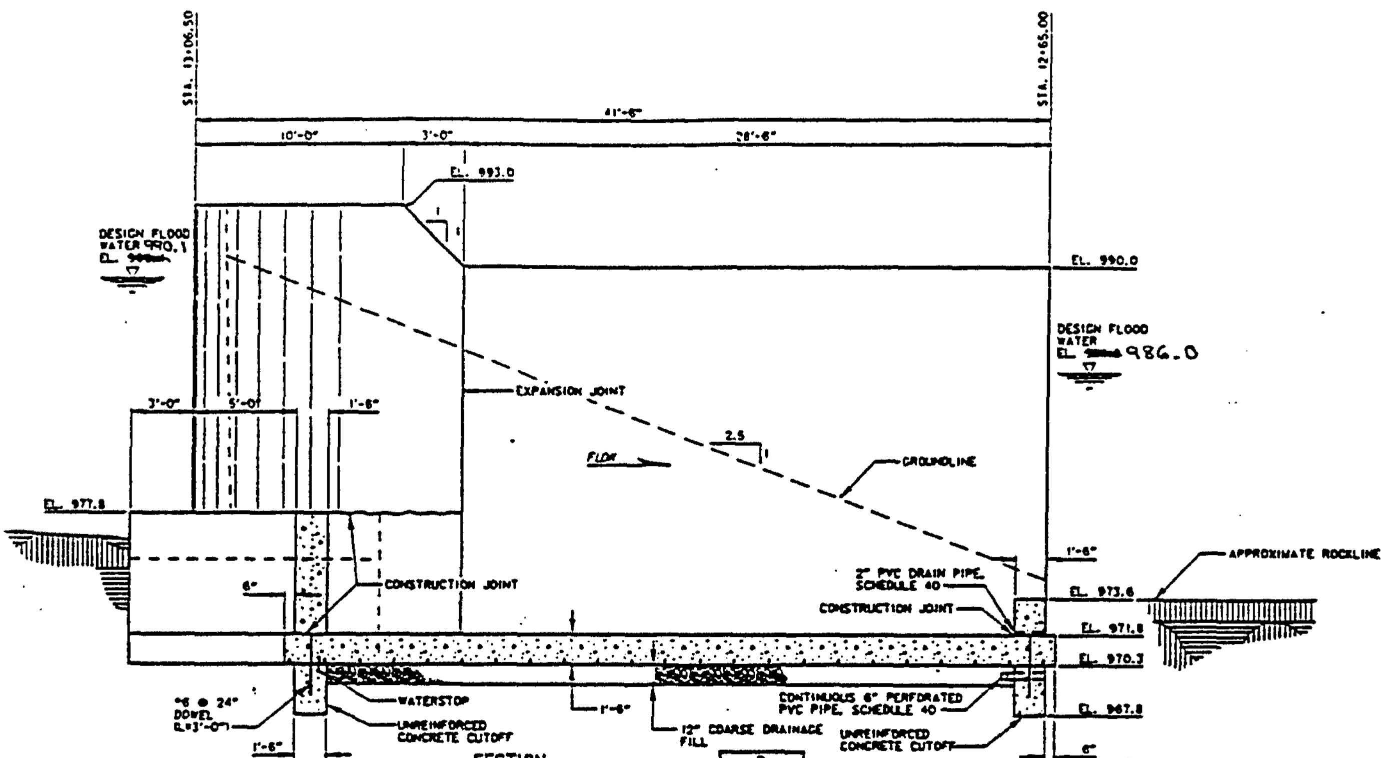
Rock Elev. at Section A

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 Oct '91	PAGE 3 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION D/S Drop Structure	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	



SECTION
DROP STRUCTURE

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 Oct '91	PAGE 4 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	



SECTION B
DROP STRUCTURE PLATE 35
SCALE: 1/4" = 1'-0"

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 21 Oct '91	PAGE 5 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Note: For overturning and bearing use at-rest pressure conditions and for design of structural elements use at-rest earth pressures on the driving side (EM 1110-2-2502, para 3-7b)

At-rest earth pressure coefficient

$SMF = 2/3$

$\phi_d = \tan^{-1}(2/3 \tan\phi)$ (developed angle of internal friction on slip plane of wedge)

$= \tan^{-1}(2/3 \tan 33°) = 23.4°$

$K_a = \tan^2(45° - \frac{\phi_d}{2})$ for driving pressure (Eq 3-15, EM 2502

$= \tan^2(45° - \frac{23.4}{2}) = \underline{0.43}$

$H_1 = \frac{1}{2} K_a \gamma_{sub} h^2$ (Eq. 3-16, EM 2502)

$= 1/2 (0.43)(62.5\ \text{lb/ft}^3)(10.0\text{ft})^2$

$H_1 = \underline{1.34^K}$

$H_{w1} = \frac{1}{2}\gamma_w h^2 = \frac{1}{2}(62.5\ \text{lb/ft}^3)(20.1')^2 = \underline{12.6^K}$

$K_p = K_o = 1 - \sin\phi$ for resisting pressure (See EM 2502 par. 3-8b)

$= 1 - \sin 33° = \underline{0.46}$ (Eq 3-4, EM 2502)

$H_2 = 1/2 K_p \gamma_{sub} h^2 = \frac{1}{2}(0.46)(62.5\ pcf)(5.8')^2 = \underline{0.48^K}$

$H_{w2} = 1/2 \gamma_w h^2 = 1/2 (62.5)(18.2')^2 = \underline{10.4^K}$

$H_{w3} = \frac{1}{2}(62.5)(18.3)^2 = \underline{10.5^K}$

$H_{w4} = 1/2 (62.5)(14.2')^2 = \underline{6.3^K}$

$W_1 = (14.2')(35')(1')(62.5\ \text{lb/ft}^3) = \underline{31.1^K}$

$W_2 = (1.5')(10.0')(1')(150\ \text{lb/ft}^3) = \underline{2.3^K}$

$W_3 = (1.5)(36.5')(1')(150\ \text{lb/ft}^3) = \underline{8.2^K}$

$W_4 = (1.0')(4.3')(1')(150) = \underline{0.6^K}$

$W_5 = \frac{1}{2}(1.0')(35.0')(4.1')(62.5\ pcf) = \underline{4.5^K}$

$W_6 = 1.0'(1.5')(12.3')(62.5\ pcf) = \underline{1.2^K}$

$W_7 = 1.0'(1.0')(12.4')(62.5\ pcf) = \underline{0.8^K}$

$W_8 = (0.5)(1.0')(14.2')(62.5\ pcf) = \underline{0.4^K}$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 22 Oct '91	PAGE 6 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION D/S Drop Structure	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Uplift: Assume the total seepage path length is the base width when the foundation is on rock (EM 2502, para. 3-22). ∴ Full hydrostatic pressures will exist at pts. A + B (EL.986.0-970.3=15.7')

$u_A = 15.7'(62.5\text{ pcf}) = 0.98\text{ ksf}$

$u_B = 19.8'(62.5\text{ pcf}) = 1.23\text{ ksf}$

$\therefore u_1 = (0.98\text{ ksf})(38.0')(1') = 37.2^K$

$u_2 = \frac{1}{2}(1.23-0.98\text{ ksf})(38')(1') = 4.8^K$

Overturning Stability Analysis: (about pt. A, fig. on pg 1)

Force (K)	Arm (ft.)	Moment (ft-K)
W_1 = 31.1	18.5	575.4
W_2 = 2.3	36.75	84.5
W_3 = 8.2	18.5	151.7
W_4 = 0.6	0.5	0.3
W_5 = 4.5	24.33	109.5
W_6 = 1.2	36.75	44.1
W_7 = 0.8	0.5	0.4
W_8 = 0.4	−0.25	−0.1
u_1 = −37.2	19.0	−706.8
u_2 = −4.8	25.3	−121.4
$\Sigma V = 7.1^K$		
H_{w3} = 10.5	10.1	106.1
H_{w1} = −15.5	7.4	−115.2
H_1 = −1.34	3.3	−4.4
H_{w2} = 10.4	6.1	63.1
H_2 = 0.48	1.9	0.9
H_{w4} = −6.3	8.7	−55.0
$\Sigma H = -1.8^K$		$\Sigma M_A = 133.1'^K$

$$\therefore x_R = \frac{\Sigma M_A}{\Sigma V} = \frac{133.1'^K}{7.1^K} = 18.8^{ft}$$

width of base in compression $= 3x_R = 56.2^{ft}$

% in compression $= \frac{56.2}{38.0'} = 148\% > 50\%$ recommended for rock-foundation (EM 2502, Table 4-1) ∴ OK

∴ Overturning criterion is satisfied

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 23 Oct '91	PAGE 7 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Sliding Stability Analysis: Note: Bearing on bedrock

$N' = \Sigma V = 7.1^K$

$T = \Sigma H = 1.8^K$

$F.S. = 1.33$ (Table 4.1, EM 2502)

$$T \leq \frac{N' \tan\phi + cL}{F.S.}$$ (Eq. 4-12, EM 2502)

$L = 38'$

$c = 50 \text{ psi} \times \frac{1K}{1000^{\#}} \times \frac{144 \text{ in}^2}{1 \text{ ft}^2} = 7.2 \text{ Ksf}$ (See pg 1)

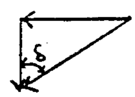
$\phi = 0$ for bedrock (pg 1)

$$1.8^K \leq \frac{(\overset{c}{7.2 \text{ ksf}})(\overset{L}{38'})(\overset{width}{1'})}{1.33}$$

$1.8^K \leq 206^K$ $\therefore$ OK, Sliding criterion is satisfied

Bearing Capacity Analysis: (Chap. 5, EM 2502)

Load inclination, $\delta = \tan^{-1}\left(\frac{\Sigma H}{\Sigma V}\right)$



$\delta = \tan^{-1}\left(\frac{1.8}{7.1}\right) = 14.22°$

$e = \frac{B}{2} - x_R = \frac{38'}{2} - 18.8' = 0.2'$

$\bar{B} = B - 2e = 38' - 2(0.2') = 37.6'$ (effective width)

$D = 5.8'$ (depth of material in front of drop structure to base of structural wedge)

$\gamma_{sat} = 160$ pcf

$\gamma_{sub} = 160 - 62.5 \text{ pcf} = 97.5 \text{ pcf}$

$q_0 = \gamma_{sub} \cdot D = (97.5 \text{ pcf})(5.8') = 0.566 \text{ ksf}$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 23 Oct '91	PAGE 8 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Bearing Capacity Con't:

$$\xi_{cd} = 1 + 0.2\,(D/\bar{B})\tan(45° + \tfrac{\phi}{2})$$

$$= 1 + 0.2\left(\frac{5.8'}{37.6'}\right) = 1.031$$

$$\xi_{qd} = \xi_{\gamma d} = 1 \qquad (\text{when } \phi = 0)$$

$$\xi_{qi} = \xi_{ci} = \left(1 - \frac{\delta}{90}\right)^2 = \left(1 - \frac{14.22°}{90°}\right)^2 = 0.8420$$

$$\xi_{\gamma i} = 0 \qquad (\text{when } \delta > \phi)$$

For $\phi = 0$: $N_c = 5.14$
$N_q = 1.00$
$N_\gamma = 0.0$

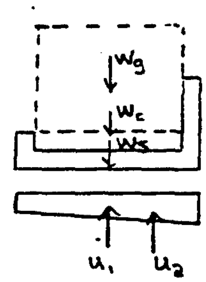
$$Q = \bar{B}\left[(\xi_{cd}\,\xi_{ci}\,\xi_{ce}\,\xi_{cg}\,c\,N_c)\right]$$

$$= 37.6'\left[\underset{\xi_{cd}}{(1.031)}\underset{\xi_{ci}}{(0.8420)}\underset{\xi_{ce}}{(1.0)}\underset{\xi_{cg}}{(1.0)}\underset{c}{(7.2\text{ ksf})}\underset{N}{(5.14)}\right]$$

$$Q = 1208^{K}$$

$$F.S. = \frac{Q}{N'} = \frac{1208}{7.1} = 170 > 2.0 \;\; \therefore \text{OK}$$, Bearing criterion is satisfied.

Flotation Stability: (ETL 1110-2-307)



$W_s = W_2 + W_3 + W_4 = 11.1\ ^{K}/\text{ft}$

$W_c = 1.8' \times 35' \times 62.5\text{pcf} = 3.9\ ^{K}/\text{ft}$

$W_g = W_1 + W_5 + W_6 + W_7 + W_8 - W_c = 34.1^{K}$

$u_1 = 37.2^{K}$ (see pg. 6)

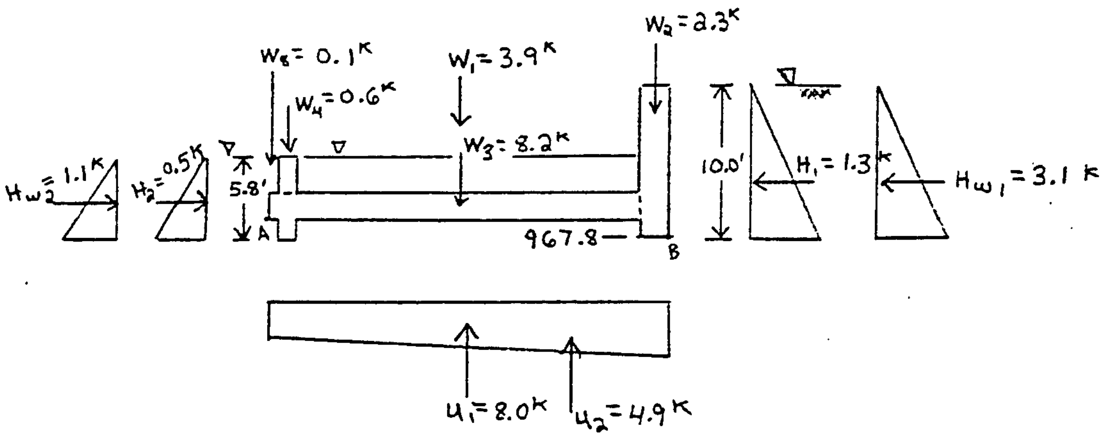
$u_2 = 4.8^{K}$

$$SF_f = \frac{W_s + W_c + S}{u - W_g}$$, where $S = 0$ (surcharge)

$$= \frac{11.1 + 3.9}{37.2 + 4.8 - 34.1} = 1.9 > 1.3 \;\; \therefore \text{OK}$$ (Unusual condition)

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 28 Oct '91	PAGE 9 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Usual Loading Condition



$H_1 = 1.3^K$ (pg 5)

$H_{w1} = \frac{1}{2}(62.5\,pcf)(10.0')^2 = 3.1^K$

$H_2 = 0.5^K$ (pg 5)

$H_{w2} = \frac{1}{2}(62.5\,pcf)(5.8')^2 = 1.1^K$

$u_A = 3.3'(62.5\,pcf) = 0.21\,ksf$

$u_B = 7.5'(62.5\,pcf) = 0.47\,ksf$

$u_1 = (0.21\,ksf)(38.0')(1') = 8.0^K$

$u_2 = \frac{1}{2}(0.47 - 0.21\,ksf)(38')(1') = 4.9^K$

W_2, W_3, W_4 same as pg 5

$W_5, W_6, W_7 = 0$

$W_8 = (0.5')(1.0')(1.8')(120\,pcf) = 0.1^K$

$W_1 = 1.8' \times 1.0' \times 0.0625\,kcf \times 35' = 3.9^K$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 28 Oct '91	PAGE 10 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Overturning:

$\xrightarrow{+}$ $\downarrow +$

Force (k)	Arm (ft)	Moment (ft-k) $\circlearrowright +$
$W_1 = 3.9$	18.5	72.2
$W_2 = 2.3$	36.75	84.5
$W_3 = 8.2$	18.5	151.7
$W_4 = 0.6$	0.5	0.3
$W_8 = 0.1$	-0.25	0.03
$U_1 = -8.0$	18.5	-148.0
$U_2 = -4.9$	24.3	-119.1
$\Sigma V = 2.2^k$		
$H_1 = -1.3$	3.3	-4.3
$H_{w1} = -3.1$	3.3	-10.2
$H_2 = 0.5$	1.9	1.0
$H_{w2} = 1.1$	1.9	2.1
$\Sigma H = -2.8^k$		$\Sigma M_A = 30.2'^k$

$$x_R = \frac{\Sigma M_A}{\Sigma V} = \frac{30.2'^k}{2.2^k} = 13.7' \quad , \quad 3x_R = 41.2'$$

$\therefore$ % in compression $= \frac{41.2'}{38'} = 108\% > 50\%$ $\therefore$ OK $\therefore$ overturning criterion is satisfied.

Sliding Stability Analysis:

$N' = \Sigma V = 2.2^k$

$T = \Sigma H = 2.8^k$

$F.S. = 1.5$

$$T \le \frac{N' \tan\phi + cL}{F.S.}$$

$$2.8^k \le \frac{(7.2\text{ ksf})(38')(1')}{1.5} = 206 \qquad \therefore \text{OK}$$

Assume bearing is OK.

Flotation Stability:

$W_S = 11.1$ k/ft (pg 8)

$W_c = 3.9$ k/ft (")

$W_g = 0$

$U = U_1 + U_2 = 8.0 + 4.9 = 12.9^k$

$$S.F_f = \frac{W_s + W_c}{U} = \frac{11.1 + 3.9}{12.9} = 1.16 < 1.5$$ $\therefore$ Look at total drop structure

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 28 Oct '91	PAGE 11 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Total Drop Structure :

wt. of side walls = 2 × 21.2′ (wall ht.) × 1.75′ (Avg. width) × 11.5′ (Avg. Length) × 150 pcf = 128.0^k
+ 2 × 18.2′ × 1.75′ × 30′ × 150 pcf = 286.7^k
+ 2 × 4.5′ × 0.5′ × 35′ × 150 pcf = 23.6^k

wt. of slab = 38′ × 80′ × 1.5′ × 150 pcf = 684.0^k

D/S wall = 1.8′ × 1.0′ × 75′ × 150 pcf = 20.2^k

U/S wall = 6.0′ × 1.5′ × 75′ × 150 pcf = 101.3^k

$W_s = 1{,}244^k$

$U_1 = (0.21\text{ ksf})(38')(80') = 638.4^k$

$U_2 = \frac{1}{2}(0.47 - 0.21\text{ ksf})(38')(80') = 395.2^k$

$U = 1{,}033.6^k$

$$S.F_f = \frac{W_s}{U} = \frac{1{,}244^k}{1033.6} = 1.2 > 1.1$$ for extreme maintenance (i.e. no water inside) ∴ OK

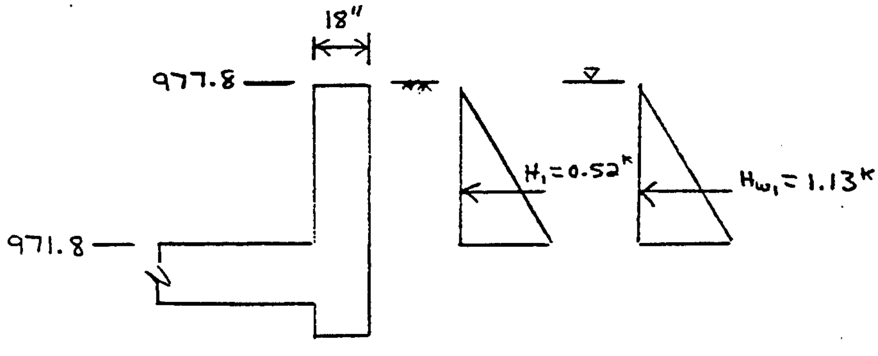
Check Normal Operation: (i.e. with water to EL 973.6)

$W_c = 1.8' \times 35' \times 75' \times 62.5\text{pcf} = 295.3^k$

$$S.F_f = \frac{W_s + W_c}{U} = \frac{1{,}244^k + 295.3^k}{1033.6^k} = 1.49 \approx 1.5$$ ∴ OK for normal operation

Wall Design:

U/S Wall:



$H = \frac{1}{2} K_o \gamma_{sub.} h^2$ (use K_o, see para. 3-7a, EM2502)

$= \frac{1}{2}(0.46)(62.5\text{pcf})(6.0)^2 = 0.52^k$

$H_{w1} = \frac{1}{2}\gamma_w h^2 = \frac{1}{2}(62.5\text{pcf})(6.0')^2 = 1.13^k$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 29 Oct '91	PAGE 12 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA Pg N-13, EM 2502		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Rein. con't:

$$M = (0.52^k + 1.13^k) \times 2.0' = 3.30'^k$$

$$M_u = 1.9\,M = 1.9(3.30'^k)\left(\frac{12^{in}}{1ft}\right) = 75.2^{in\text{-}k}$$

$$K_u = 1 - \sqrt{1 - \frac{M_u}{0.425 f'_c\, b d^2 \phi}} \quad , b = 12'', d = 18'' - 4.5'' = 13.5''$$

$$= 1 - \sqrt{1 - \frac{75^{in\text{-}k}}{0.425(4\text{ ksi})(12'')(13.5'')^2(0.9)}}$$

$$K_u = 0.0113$$

$$C_u = T_u = 0.85 f'_c\, k_u\, bd$$

$$= 0.85(4\text{ ksi})(0.0113)(12'')(13.5'') = 6.2^k$$

$$A_s = \frac{T_u}{f_y} = \frac{6.2^k}{48\text{ksi}} = 0.13^{in^2}/ft \Rightarrow \#4 @ 12^{in} \; (A_s = 0.20^{in^2}/ft)$$

Check Ductility: $\rho_{min} \le \rho \le \rho_{max}$

$\rho_{min} = \frac{200}{f_y} = \frac{200}{48{,}000} = 0.00417$ (EM 2502, par. 9-8b(4) + ACI 10.5.1)

$\rho_{max} = 0.0097$ for $f'_c = 4$ ksi (ETL 1110-2-265, pg 1-14)

$\rho = \frac{A_s}{bd} = \frac{0.20^{in^2}}{(12'')(13.5'')} = 0.00123 < \rho_{min}$ ∴ NG.

can use $\rho = 4/3(0.00123 = 0.0016$ (ACI 10.5.2) but use ρ_{min}.

∴ Use $\rho_{min} \Rightarrow A_s = (0.00417)(12'')(13.5'') = 0.68^{in^2}/ft$

$\boxed{\therefore \text{ use } \#6 @ 8'' \; (A_s = 0.66^{in^2}/ft) \text{ for u/s wall}}$

Use 4" cover on drop wall + sill wall because both sides are exposed to weather.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 29 Oct.'91	PAGE 13 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Temperature & Shrinkage (See EM 1110-2-xxxx, 31 Jan'90) (Pg 2-3)

For non-massive members the area of reinf. should be 0.0018 times the gross cross-sectional area, half in each face times 25% when exposed to weather.

$\therefore \varphi = 0.0018 \times (1.25) = \underline{0.00225}$

$\therefore A_s = 0.00225 b \cdot h$

$= 0.0018 (12'')(18'') = 0.48 \text{ in}^2/\text{ft}$

$\frac{1}{2} A_s = 0.24 \text{ in}^2/\text{ft}$

$\therefore$ Use #5 @ 12 in. each face ($A_s = 0.31 \text{ in}^2/\text{ft}$.)
for temp. & shrinkage for U/S wall

D/S Wall:

Assume $\varphi_{min.}$ will also be used for D/S wall

$b = 12''$

$d = 12'' - 3.5'' = 8.5''$

$\varphi = (0.00417)(12'')(8.5'') = 0.43 \text{ in}^2/\text{ft}$

$\therefore$ Use #6 @ 12" ($A_s = 0.44 \text{ in}^2/\text{ft}$) for D/S wall

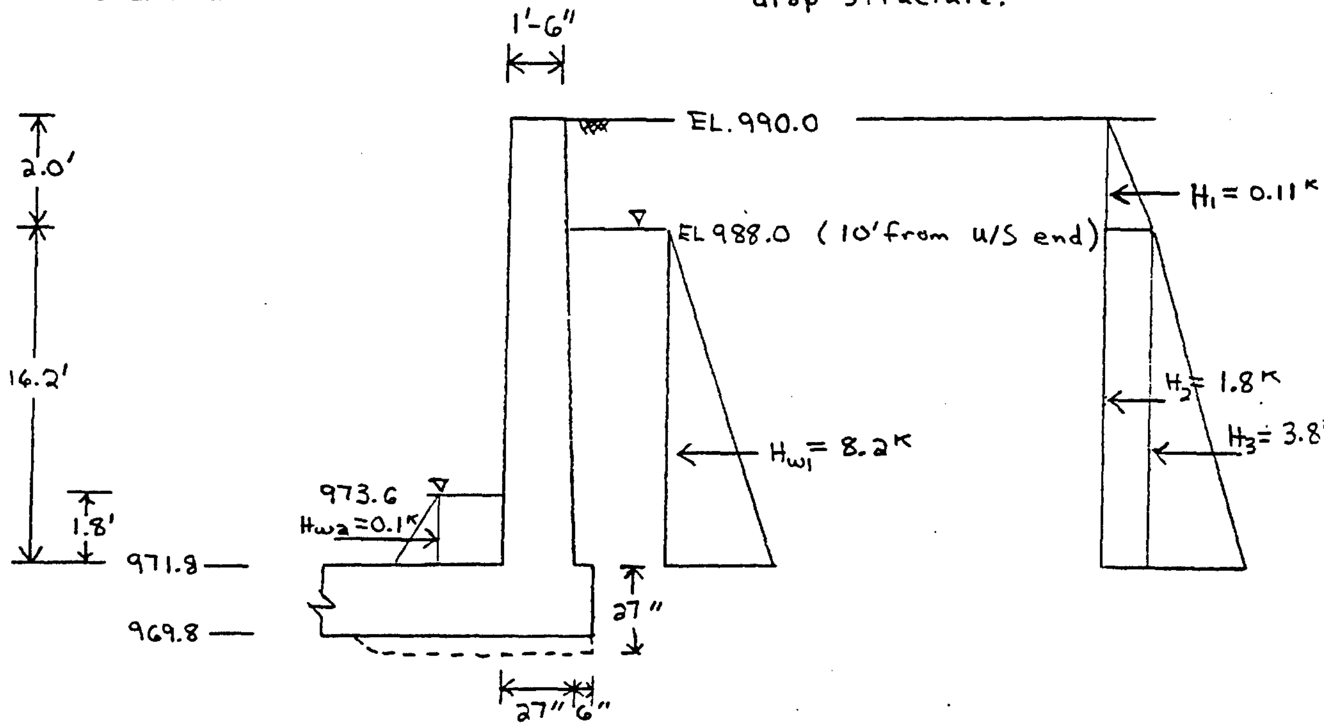
temp. & shrinkage: $\frac{1}{2} A_s = \frac{1}{2}(0.00225)(12'')(12'') = 0.16 \text{ in}^2/\text{ft}$

Use #4 @ 12 in. each face ($A_s = 0.20 \text{ in}^2/\text{ft}$)
for temp. & shrankage for D/S wall

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 29 Oct '91	PAGE 14 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA ED-GH memo 10-15-91		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

B. Look at Section B-B (pg. 3) Assume stability of side walls are OK because Lateral Loads are the same on both sides of drop structure.

Side Walls:



$H_{w1} = \frac{1}{2}\gamma_w h^2 = \frac{1}{2}(62.5\text{ pcf})(16.2')^2 = 8.2^K$

$H_{w2} = \frac{1}{2}(62.5\text{pcf})(1.8')^2 = 0.1^K$

$H_1 = \frac{1}{2}\gamma_{Moist} K_o h^2 = \frac{1}{2}(120\text{pcf})(0.46)(2.0')^2 = 0.11^K$

$H_2 = \gamma_{moist} K_o h_1 \cdot h_2 = (120\text{pcf})(0.46)(2.0')(16.2') = 1.8^K$

$H_3 = \frac{1}{2}\gamma_{sub} K_o h^2 = \frac{1}{2}(62.5\text{pcf})(0.46)(16.2')^2 = 3.8^K$

$M = \overset{H_1}{(0.11^K)}(16.9') + \overset{H_2}{(1.8^K)}(8.1') + \overset{H_3}{(3.8^K)}(5.4') + \overset{H_{w1}}{(8.2^K)}(5.4') - \overset{H_{w2}}{(0.1^K)}(0.6'$

$M = 1.9'^K + 14.6'^K + 20.5^K + 44.3'^K - 0.06'^K = \underline{81.2'^K}$

$M_u = 1.9 M = 1.9(81.2'^K)(12^{in}/ft) = 1,852^{in-K}$

$b = 12"$

$d = 24" - 4.5" = 19.5"$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 31 Oct '91	PAGE 15 OF	FILE NUMBER

NAME OF OFFICE	COMPUTATION D/S Drop Structure

SUBJECT Rochester Stage 4 FDM	SOURCE DATA

COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY

$$K_u = 1 - \sqrt{1 - \frac{M_u}{0.425\, f_c' b d^2 \phi}}$$

$$= 1 - \sqrt{1 - \frac{(1{,}852^{\text{in-k}})}{(0.425)(4\text{ksi})(12'')(19.5'')^2(0.9)}}$$

$\therefore K_u = 0.1428$

$C_u = T_u = 0.85 f_c' k_u b d$

$= 0.85(4\text{ksi})(0.1428)(12'')(19.5'') = 113.6^k$

$\therefore A_s = \frac{T_u}{f_y} = \frac{113.6^k}{48\text{ ksi}} = 2.37^{\text{in}^2/\text{ft}} \Rightarrow$ #10@ 6" ($A_s = 2.53^{\text{in}^2/\text{ft}}$)

Check DuctiLity :

$\rho = \frac{A_s}{bd} = \frac{(2.53^{\text{in}^2/\text{ft}})}{(12'')(19.5'')} = 0.0108 > \rho_{max} = 0.0097$ $\therefore$ NG

Try wider base , h = 27"

d = 27" − 4.5" = 22.5"

$$k_u = 1 - \sqrt{1 - \frac{1852^{''k}}{(0.425)(4\text{ksi})(12'')(22.5'')^2(.9)}} \quad 0.1052$$

$T_u = 0.85(4\text{ksi})(0.1052)(12'')(22.5'') = 96.5^K$

$A_s = \frac{96.5^k}{48\text{ ksi}} = 2.01^{\text{in}^2/\text{ft}} \Rightarrow$ #9 @ 6" ($A_s = 2.0\ \text{in}^2/\text{ft}$)

$\rho = \frac{2.0^{\text{in}^2/\text{ft}}}{(12)(22.5)} = 0.0074 < \rho_{max} = 0.0097$

$> \rho_{min} = 0.0042$ $\therefore$ OK

use base width = 27" & #9@ 6"
also increase sLab to 27" near
the wall-sLab connection

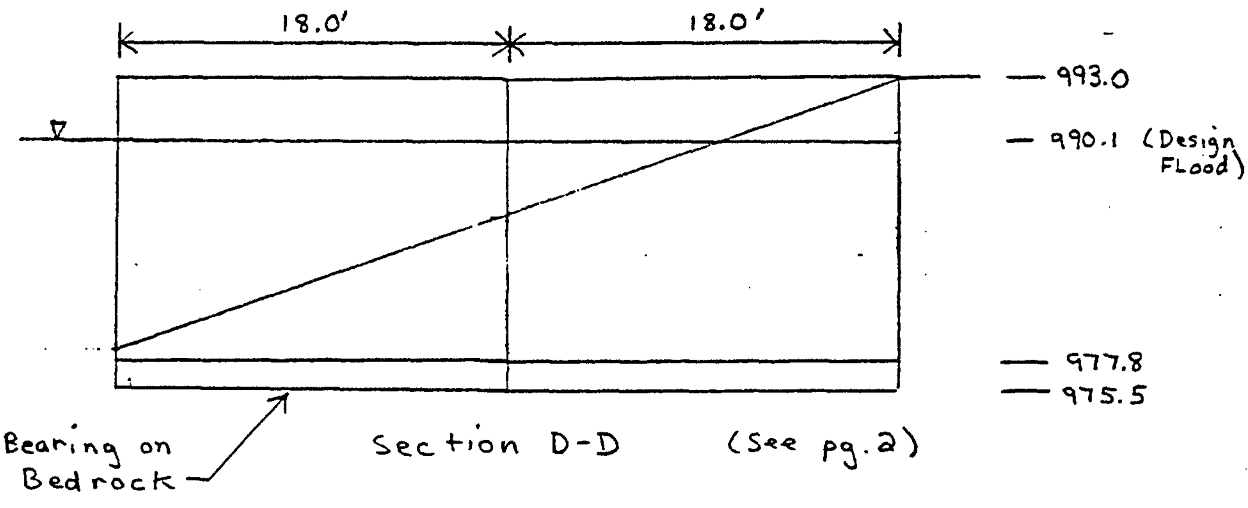
ST. PAUL DISTRICT COMPUTATION SHEET	DATE 31 Oct '91	PAGE 16 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION D/S Drop Structure	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

<u>Temp. & Shrinkage:</u>

A_s in each face $= \frac{1}{2}(0.00225)(12'')(27'') = 0.36\ \text{in}^2/\text{ft}$

$\therefore$ Use #5 @ 12" ($A_s = 0.31\ \text{in}^2/\text{ft}$) each face for temp. & shrink for side walls

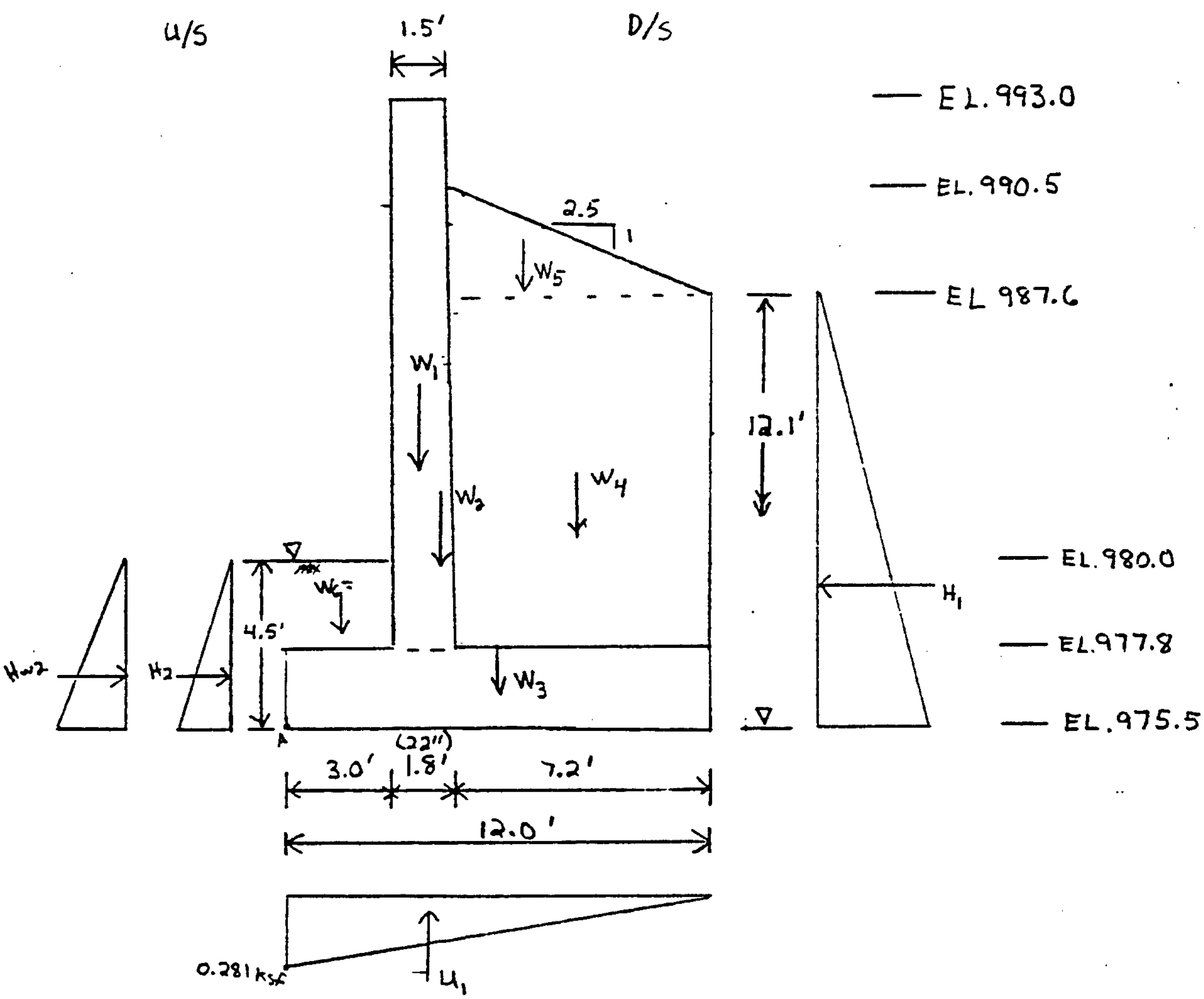
<u>C. Look at U/S Wing Walls:</u>



Section D-D (See pg. 2)

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-27-92.	PAGE 17 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION D/S Drop Structure	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

U/S Wing Wall:



$K_{a\beta} = K_o (1 + \sin\beta)$ (EM 2502, Eq 3-5)

$\beta = -\tan^{-1}(\frac{1}{2.5}) = -21.8°$

$K_o = 0.46$ (Pg 5)

$\therefore K_{a\beta} = (0.46)(1 + \sin(-21.8°)) = \underline{0.29}$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-27-92	PAGE 18 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Wing Wall con't:

$H_1 = \frac{1}{2}(0.29)(125\text{ pcf})(12.1')^2 = 2.7^K$

$H_2 = \frac{1}{2}(0.46)(62.5\text{ pcf})(4.5')^2 = 0.3^K$

$H_{w2} = \frac{1}{2}(62.5\text{ pcf})(4.5')^2 = 0.6^K$

$W_1 = (1.5')(15.2')(1')(150\text{ pcf}) = 3.4^K$

$W_2 = \frac{1}{2}(0.33')(15.2')(1')(150\text{ pcf}) = 0.4^K$

$W_3 = (2.3')(12.0')(1')(150\text{ pcf}) = 4.1^K$

$W_4 = (7.2')(9.8')(1')(120\text{ pcf}) = 8.5^K$

$W_5 = \frac{1}{2}(2.9')(7.2')(1')(120\text{ pcf}) = 1.3^K$

$W_6 = (2.2')(3.0')(1')(125\text{ pcf}) = 0.8^K$

Uplift:

$u_A = (4.5')(62.5\text{ pcf}) = 0.281\text{ ksf}$

$u_1 = 0.281\text{ ksf}(12.0')(1.0') = 3.4^K$

Overturning Stability Analysis: (about pt. A)

$\xrightarrow{+}$ $\downarrow +$ Force (K)	Arm (ft)	Moment (Ft-K) (+)
$W_1 = 3.4$	3.75	12.8
$W_2 = 0.4$	4.67	1.9
$W_3 = 4.1$	6.0	24.6
$W_4 = 8.5$	8.4	71.4
$W_5 = 1.3$	7.2	9.4
$W_6 = 0.8$	1.5	1.2
$u_1 = -3.4$	4.0	-13.6
$\Sigma V = 15.1$		
$H_1 = -2.7$	4.0	-10.8
$H_2 = 0.3$	1.5	0.5
$H_{w2} = 0.6$	1.5	0.9
$\Sigma H = -1.8$		$\Sigma M = 98.3'^K$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-27-92	PAGE 19 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION D/S Drop Structure	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Wing Wall Con't:

$x_R = \frac{\Sigma M}{\Sigma V} = \frac{98.3'^K}{15.1^K} = 6.5'$ which is $> 4.0'$ & $< 8.0'$ ∴ in Kern

∴ Overturning criterion is satisfied

Sliding Stability Analysis: Note: Bearing on bedrock

$N' = \Sigma V = 15.1^K$

$T = \Sigma H = 1.8^K$

$T \leq \frac{N' \tan\phi + cL}{F.S.}$, $\phi = 0$, $c = 7.2^{ksf}$, $L = 12'$, $F.S. = 1.5$

$1.8^K \leq \frac{(7.2^{ksf})(12')(1')}{1.5} = 57.6^K$ ∴ O.K., sliding criteria is satisfied

Bearing Capacity Analysis:

$\delta = \tan^{-1}\left(\frac{\Sigma H}{\Sigma V}\right) = \tan^{-1}\left(\frac{1.8}{15.1}\right) = 6.80°$

$e = x_R - \frac{B}{2} = 6.5' - 6.0' = 0.5'$

$\bar{B} = B - 2e = 12' - 2(0.5') = 11.0'$

$D = 4.5'$

$q_o = \gamma_{sub} \cdot D = (62.5 pcf)(4.5') = 0.281$ ksf

$\xi_{qd} = \xi_{\gamma d} = 1.0$

$\xi_{cd} = 1 + 0.2(D/\bar{B}) \tan(45° + \frac{\phi}{2}) = 1 + 0.2\left(\frac{4.5}{11.0}\right) = 1.0818$

$\xi_{ci} = \xi_{qi} = \left(1 - \frac{\delta°}{90°}\right)^2 = \left(1 - \frac{6.80}{90}\right)^2 = 0.8546$

$\xi_{\gamma i} = 0$

$\xi_{qt} = \xi_{\gamma t} = 1.0$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-30-92	PAGE 20 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Bearing Con't:

$$\xi_{\gamma g} = \xi_{gg} = [1 - \tan\beta]^2 = [1 - \tan(21.8°)]^2 = 0.360$$

$$N_g = 1.0, \quad N_\gamma = 0.0, \quad N_c = 5.14$$

$$\xi_{ct} = 1.0 \qquad \beta = 21.8° = 0.3805 \text{ radians}$$

$$\xi_{cg} = 1 - \left[\frac{2\beta}{(\pi+2)}\right] = 1 - \left[\frac{2(0.3805)}{(\pi+2)}\right] = 0.852$$

$$Q = \bar{B}\left[(\xi_{cd}\,\xi_{ci}\,\xi_{ct}\,\xi_{cg}\,c\,N_c) + (\xi_{gd}\,\xi_{gi}\,\xi_{gt}\,\xi_{gg}\,g_o\,N_g)\right]$$

$$= 11.0'\left[\overset{\xi_{cd}}{(1.0818)}\overset{\xi_{ci}}{(0.8546)}\overset{\xi_{ct}}{(1.0)}\overset{\xi_{cg}}{(0.852)}\overset{c}{(7.2\text{ ksf})}\overset{N_c}{(5.14)} + \overset{\xi_{gd}}{(1.0)}\overset{\xi_{gi}}{(0.8546)}\overset{\xi_{gt}}{(1.0)}\overset{\xi_{gs}}{(0.360)}\overset{g_o}{(0.281\text{ ksf})}\overset{N_g}{(1.0)}\right]$$

$$\therefore Q = 322^k$$

$$F.S. = \frac{Q}{N'} = \frac{322^k}{15.1^k} = 21 > 3.0$$ $\therefore$ OK, bearing criterion is satisfied

Check Flotation:

$$W_s = W_1 + \cdots + W_6 = 18.5^k$$

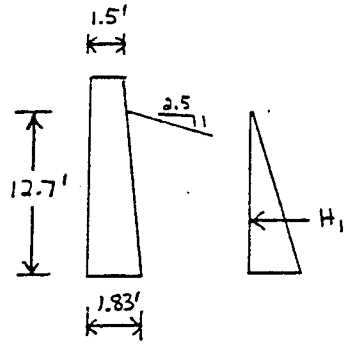
$$u = u_1 = 3.4^k$$

$$\therefore SF_f = \frac{W_s}{u} = \frac{18.5^k}{3.4^k} = 5.4 > 1.5$$ for usual cond. $\therefore$ OK

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-30-92	PAGE 21 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Wall Design:

A. Base of Stem:



$H_1 = \frac{1}{2}(0.29)(125\ pcf)(12.7')^2 = 2.92^k$

$M = 2.92^k \times 4.23' = 12.4'^k$

$M_u = 1.9\,M = 23.5'^k = 281.8^{\text{in-k}}$

$b = 12''$

$d = 22'' - 4.5'' = 17.5''$

$$k_u = 1 - \sqrt{1 - \frac{M_u}{0.425 f'_c b d^2 \phi}}$$

$$k_u = 1 - \sqrt{1 - \frac{(281.8^{\text{in-k}})}{0.425(4)(12)(17.5)^2(0.9)}} = 0.0254$$

$C_u = T_u = 0.85 f'_c k_u bd$

$= 0.85(4\ ksi)(0.0254)(12'')(17.5'') = 18.1^k$

$A_s = \frac{T_u}{f_y} = \frac{18.1^k}{48\ ksi} = 0.38\ in^2/ft$

$\rho = \frac{A_s}{bd} = \frac{0.38\ in^2/ft}{(12'')(17.5'')} = 0.0018$

use $\rho = \frac{4}{3}(0.0018) = 0.0024$ (ACI 10.5.2)

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-30-92	PAGE 22 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT R..chester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Stem con't:

$$\therefore A_s = (0.0024)(12'')(17.5'') = 0.50 \ in^2/ft.$$

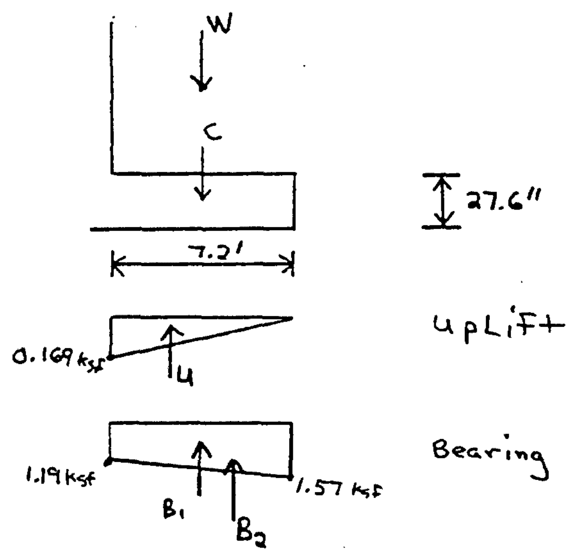
∴ Use #5@6 in. ($A_s = 0.61 \ in^2/ft$) for stem,
top width of stem = 18"
base width of stem = 22"

Temp. & Shrinkage:

$$\tfrac{1}{2} A_s = \tfrac{1}{2}(0.00225)(12'')(\overset{Avg.\,h}{20''}) = 0.27 \ in^2/ft$$

∴ Use #5 @ 12" E.F. ($A_s = 0.31 \ in^2/ft$) for temp. & shrinkage

B. Heel at Face of Stem:



Bearing Pressure:

$$p = \frac{\Sigma V}{b}\left(1 + \frac{6e}{b}\right)$$

$\Sigma V = 15.1^K$ (pg 18)

$e = 0.5'$ (pg 19)

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-30-92	PAGE 23 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Heel con't:

$$p_1 = \frac{15.1^k}{12.0'}\left(1 + \frac{6(0.5')}{12.0}\right) = 1.57 \text{ ksf}$$

$$p_2 = \frac{15.1}{12.0}\left(1 - \frac{6(0.5)}{12.0}\right) = 0.94 \text{ ksf}$$

$$\therefore B_1 = 1.19 \text{ ksf}(7.2')(1') = 8.6^k$$

$$B_2 = \tfrac{1}{2}(1.57 - 1.19 \text{ ksf})(7.2')(1') = 1.4^k$$

$$u = \tfrac{1}{2}(0.169 \text{ ksf})(7.2')(1.0') = 0.61^k$$

$$c = \left(\tfrac{27.6}{12}\right)(7.2')(1')(150 \text{ pcf}) = 2.5^k \quad \text{(conc. wt.)}$$

$$W = W_4 + W_5 = 9.8^k \quad (\text{pg } 18)$$

Moment:

$$9.8^k \times 3.6' = 35.3'^k$$
$$2.5^k \times 3.6' = 9.0'^k$$
$$-0.61^k \times 2.4' = -1.5'^k$$
$$-1.4^k \times 4.8' = -6.7'^k$$
$$-8.6^k \times 3.6' = \underline{-30.9'^k}$$
$$5.2'^k$$

$$\frac{M_u}{\phi} = \frac{1.9(5.2'k)(12 \text{ in/ft})}{(0.9)} = 132^{\text{in-k}}$$

$$b = 12'' \;,\; d = 27.6'' - 4.5'' = 23.1''$$

$$0.425 f'_c b d^2 = 0.425(4)(12)(23.1)^2 = 10{,}886^{\text{in-k}}$$

$$k_u = 1 - \sqrt{1 - \frac{132}{10{,}886}} = 0.0061$$

$$C_u = T_u = 0.85(4 \text{ ksi})(0.0061)(12'')(23.1'') = 5.7^k$$

$$A_s = \frac{5.7^k}{48 \text{ ksi}} = 0.12 \text{ in}^2/\text{ft}$$

$$\rho = \frac{0.12 \text{ in}^2}{(12)(23.1)} = 0.0004 < \rho_{min} = 0.00225$$

Heel con't:

$\therefore A_s = (0.00225)(12'')(23.1'') = 0.62\ in^2/ft$

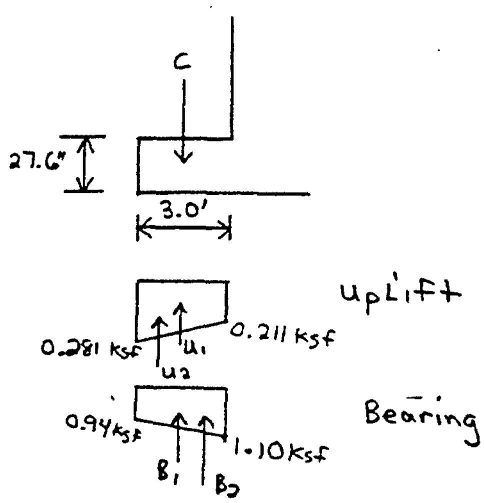
$\therefore$ Use #5 @ 6 in. ($A_s = 0.61\ in^2/ft$) in top of heel for main rein.

Temp. & Shrink. $\frac{1}{2} A_s = \frac{1}{2}(0.00225)(12'')(27.6'') = 0.37\ in^2/ft.$

$\therefore$ Use #5 @ 9" ($A_s = 0.46\ in^2/ft$) for temp. & shrinkage in heel

C. Toe at Face of Stem:

Note: Since min. depth of earth over toe, assume no soil or water on toe.



$C = \left(\frac{27.6}{12}\right)(3.0)(1)(150\ pcf) = -1.0^k \quad \times 1.5' = -1.5'^k$

$u_1 = (0.211\ ksf)(3.0')(1.0') = 0.6^k \quad \times 1.5' = 0.9'^k$

$u_2 = \frac{1}{2}(0.281 - 0.211\ ksf)(3.0)(1') = 0.1^k \quad \times 2.0' = 0.2'^k$

$B_1 = (0.94\ ksf)(3.0)(1.0') = 2.8^k \quad \times 1.5' = 4.2'^k$

$B_2 = \frac{1}{2}(1.10 - 0.94\ ksf)(3.0)(1.0) = 0.2^k \quad \times 1.0' = 0.2'^k$

$4.0'^k = M$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-30-92	PAGE 25 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION D/S Drop Structure	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Toe Con't.:

$$\frac{M_u}{\phi} = \frac{1.9(4.0'^{k})(12\ ^{in}/_{ft})}{0.9} = 101^{\ in-k}$$

$$K_u = 1 - \sqrt{1 - \frac{101^{\ in-k}}{0.425(4)(12)(23.1)^2}} = 0.0047$$

$$C_u = T_u = 0.85(4\ ksi)(0.0047)(12'')(23.1'') = 4.4^{k}$$

$$A_s = \frac{4.4^{k}}{48\ ksi} = 0.09\ ^{in^2}/_{ft}$$

$$\rho = \frac{0.09}{12(23.1)} = 0.0003 < \rho_{min.}$$

$$\therefore\ A_s = (0.00225)(12'')(23.1'') = 0.62\ ^{in^2}/_{ft}$$

∴ use #5 @ 6 in. ($A_s = 0.61\ ^{in^2}/_{ft}$) in bottom of toe for main rein.

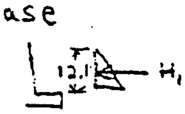
use #5 @ 9 in. ($A_s = 0.46\ ^{in^2}/_{ft}$) for temp. & shrinkage in toe

Check Shear:

The shear capacity of the concrete will be checked at a distance "d" from the base of the stem. (EM 2502, para. 9-8 f)

d = 17.1" at 17.5" above the base

$H_1 = 2.7^{k}$ (pg 17, 18)



$$V_x = \frac{W\ x^2}{L^2}$$ (AISC 2-302, #18)

$$V = \frac{2.7^{k}\left(12.1' - \frac{17.5''}{12\ ^{in}/_{ft}}\right)^2}{(12.1')^2} = 2.85^{k}$$

$$\phi V_c = 0.85(2)\sqrt{4000}(12)(17.1) = 22.1^{k} > 2.85^{k}$$ ∴ OK

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-30-92	PAGE 26 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

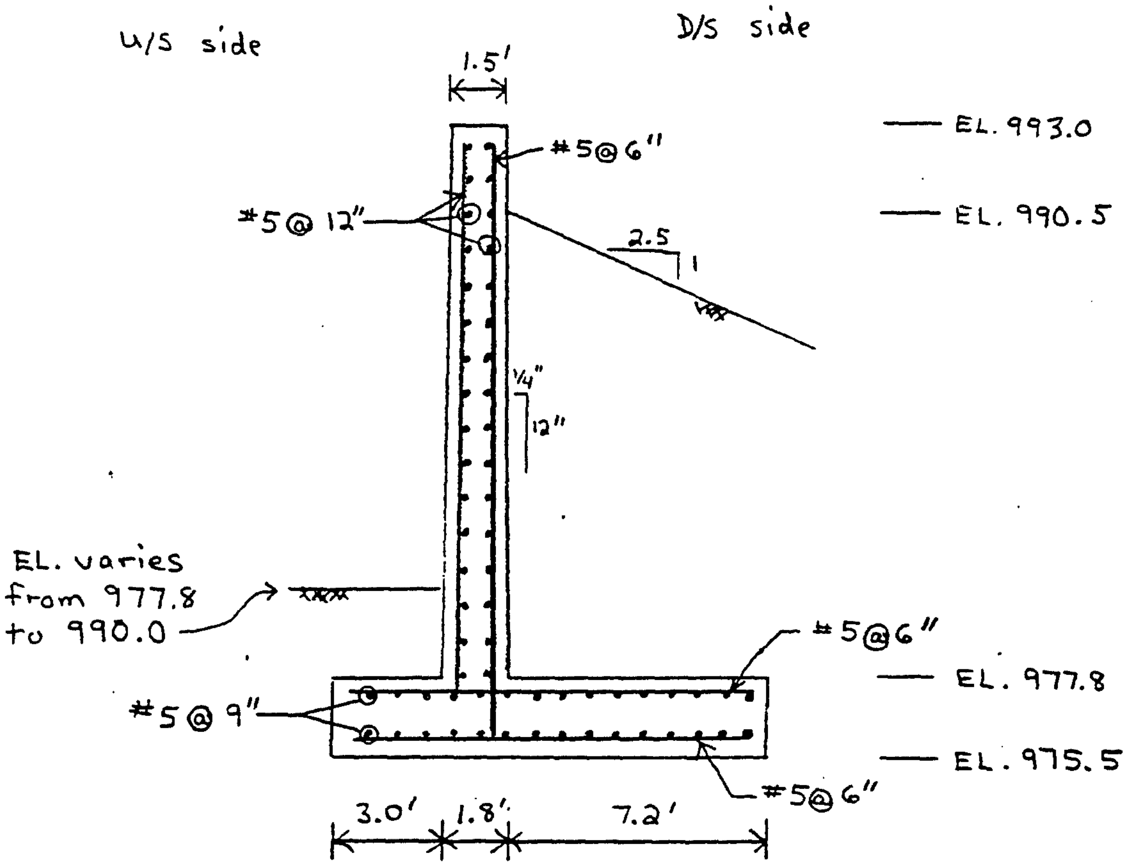
Shear Con't

Check the shear capacity of the heel at the base of the stem.

$V = W_4 + W_5 = 9.8^k$ (pg 18)

$V_u = 1.9(9.8^k) = 18.6^k$

$\phi V_c = 0.85(2)\sqrt{4000}\,(12'')(23.1'') = 29.8^k > 18.6^k \therefore OK$

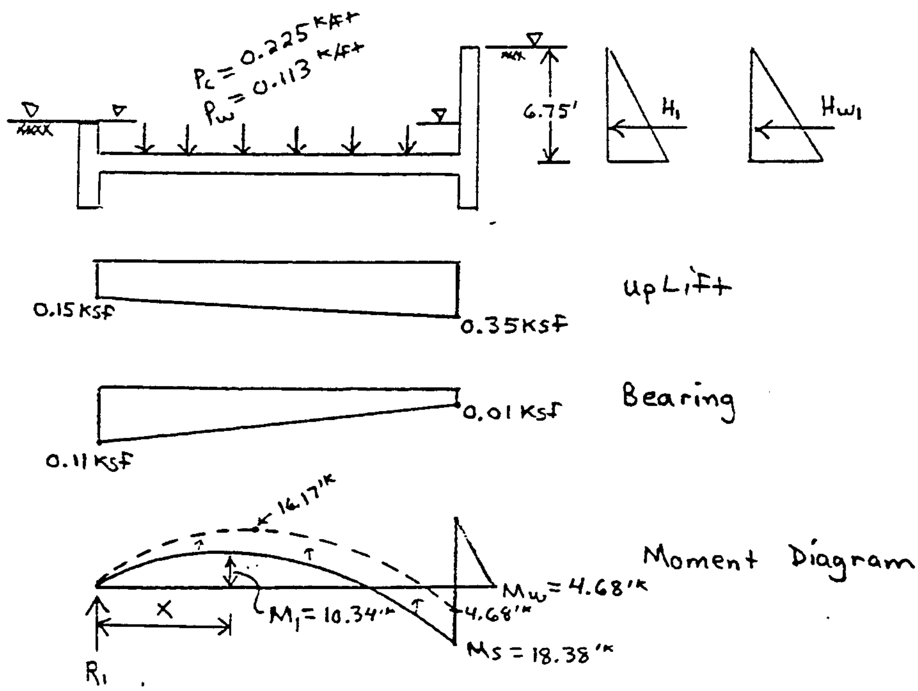


U/S Wing Wall
Scale: 1" = 5'-0"

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-31-92	PAGE 27 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Base Slab:

The base slab sits on rock, therefore no bending or deflection will occur. The steel required should be at a minimum.
But check the usual Loading condition (pg 8) which is the worst case with the upLift calculations from Geo-Tech (pg 4-5, dated 12-11-91 from D.A.C.)



$X_R = 13.7'$, $\Sigma V = 2.2^k$ (pg 10, from usual Condition)

$e = \frac{38'}{2} - 13.7' = 5.3'$

$P_1 = \frac{2.2^k}{38}\left(1 + \frac{6(5.3)}{38}\right) = 0.11$ ksf

$P_2 = \frac{2.2}{38}\left(1 - \frac{6(5.3)}{38}\right) = 0.01$ ksf

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-31-92	PAGE 28 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

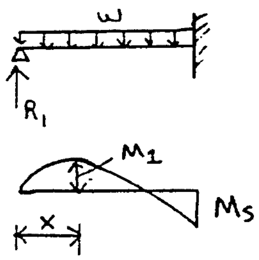
Base Slab con't:

$$H_1 = \frac{1}{2}(0.46)(0.0625\,kcf)(6.75')^2 = 0.66^K$$

$$H_{w_1} = \frac{1}{2}(0.0625)(6.75')^2 = 1.42^K$$

$$M_w = (0.66^K + 1.42^K) \times \frac{6.75'}{3} = 4.68'^K$$

For slab moment:



(See AISC #12, pg 2-299)

Try base slab thickness of 1.5'

$$\therefore\ p_c = 1.5' \times 1.0' \times 0.150\,kcf = 0.225\ K/ft$$

$$p_w = 1.8' \times 1.0' \times 0.0625\,kcf = 0.113\ K/ft$$

$$\therefore \text{Downward force} = (0.113 + 0.225\,K/ft) \times 35' = 11.8^K$$

$$+\ U/S\ \&\ D/S\ \text{walls} = (1'(1.5')(4.3') + 1' \times 1.5' \times 10.0') \times 0.150 = \underline{3.2^K}$$

$$15.0^K$$

$$\text{Upward force} = 0.15\,ksf \times 35' \times 1' + \tfrac{1}{2}(0.20)(35')(1') = 8.75^K$$

$$+\ 0.01\,ksf \times 35' \times 1' + \tfrac{1}{2}(0.10)35' \times 1' = \underline{2.10^K}$$

$$10.85^K$$

$$F.S._f = \frac{15.0^K}{10.85^K} = 1.38 > 1.1 \quad \therefore \underline{ok}$$

$$\therefore\ w = \frac{15.0^K - 10.85^K}{35'} = 0.12\ K/ft$$

$$M_s = \frac{wL^2}{8} = \frac{(0.12\,K/ft)(35')^2}{8} = 18.38'^K$$

$$R_1 = \frac{3wL}{8} = \frac{3(0.12\,K/ft)(35')}{8} = 1.58^K$$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-31-92	PAGE 29 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Base slab con't.:

$$M_1 = \frac{9}{128} wL^2 = \frac{9}{128}(0.12^k/ft)(35')^2 = 10.34'^k$$

$$x = \frac{3}{8}L = \frac{3}{8}(35') = 13.13'$$

Since the wall-slab joint will only take $4.68'^k$ (M_w) from the wall, the slab moment (M_s) will be re-distributed back into the slab. The difference in moment $= M_S - M_w = 18.38'^k - 4.68'^k = 13.70'^k$ will increase the reaction R_1 by $\Delta R = \frac{13.70'^k}{35'} = 0.39^k$ & also the moment M_1 will increase.

$$M = R_1 x - wx\left(\frac{x}{2}\right) \qquad \text{(about x)}$$

$$\frac{dM}{dx} = R_1 - wx = 0 \qquad \text{(note: max. moment when slope = 0).}$$

$$\therefore x = \frac{R_1}{w}$$

where $R_1 = 1.58^k + \overset{\Delta R}{0.39^k} = 1.97^k$

$$\therefore x = \frac{1.97^k}{0.12^k/ft} = 16.4'$$

$$\therefore M = R_1 x - \frac{wx^2}{2} = (1.97^k)(16.4') - \frac{(0.12^k/ft)(16.4')^2}{2}$$

$M = 16.17'^k$ at $16.4'$ from R_1

Check if slab can resist $16.17'^k$

$$M_u = \phi f_y \rho \left(1 - \frac{f_y \rho}{1.7 f_c'}\right) b d^2 \qquad \text{(EM 2502, pg 9-7)}$$

where $\rho = 0.0042$

$b = 12''$

$d = 18'' - 4.5'' = 13.5''$

$f_y = 48$ ksi

$f_c' = 4$ ksi

$\phi = 0.9$

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-31-92	PAGE 30 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Base Slab con't:

$$M_u = 0.9\,(48\,ksi)(0.0042)\left(1 - \frac{(48\,ksi)(0.0042)}{1.7\,(4\,ksi)}\right)(12'')(13.5'')^2$$

$$M_u = 385'^K$$

$$= 32'^K > 16.17'^K \times 1.9 = 30.7'^K \qquad \therefore \text{OK}$$

$$\therefore A_s = (0.0042)(12'')(13.5'') = 0.68\ {}^{in^2}/ft$$

$\Rightarrow$ #6 @ 6" ($A_s = 0.88\ {}^{in^2}/ft$)

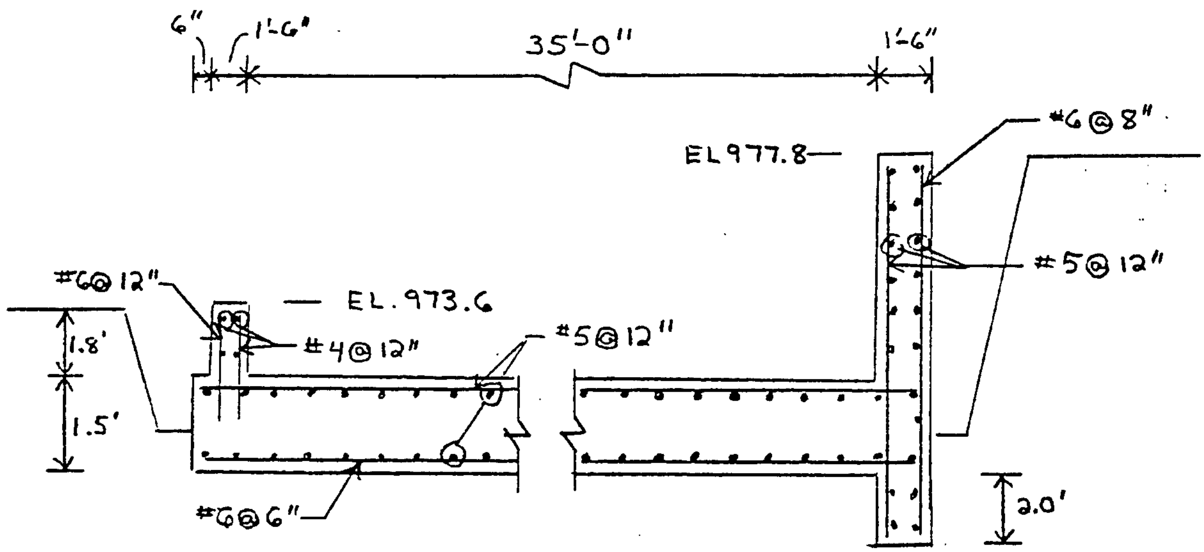
Temp. & Shrink. $= \frac{1}{2} A_s = \frac{1}{2}(0.00225)(12'')(18'') = 0.24\ {}^{in^2}/ft$

$\Rightarrow$ #5 @ 12" ($A_s = 0.31\ {}^{in^2}/ft$)

$\therefore$ Use #6 @ 6" ($A_s = 0.88\ {}^{in^2}/ft$) for bottom rein. of 18" base slab.

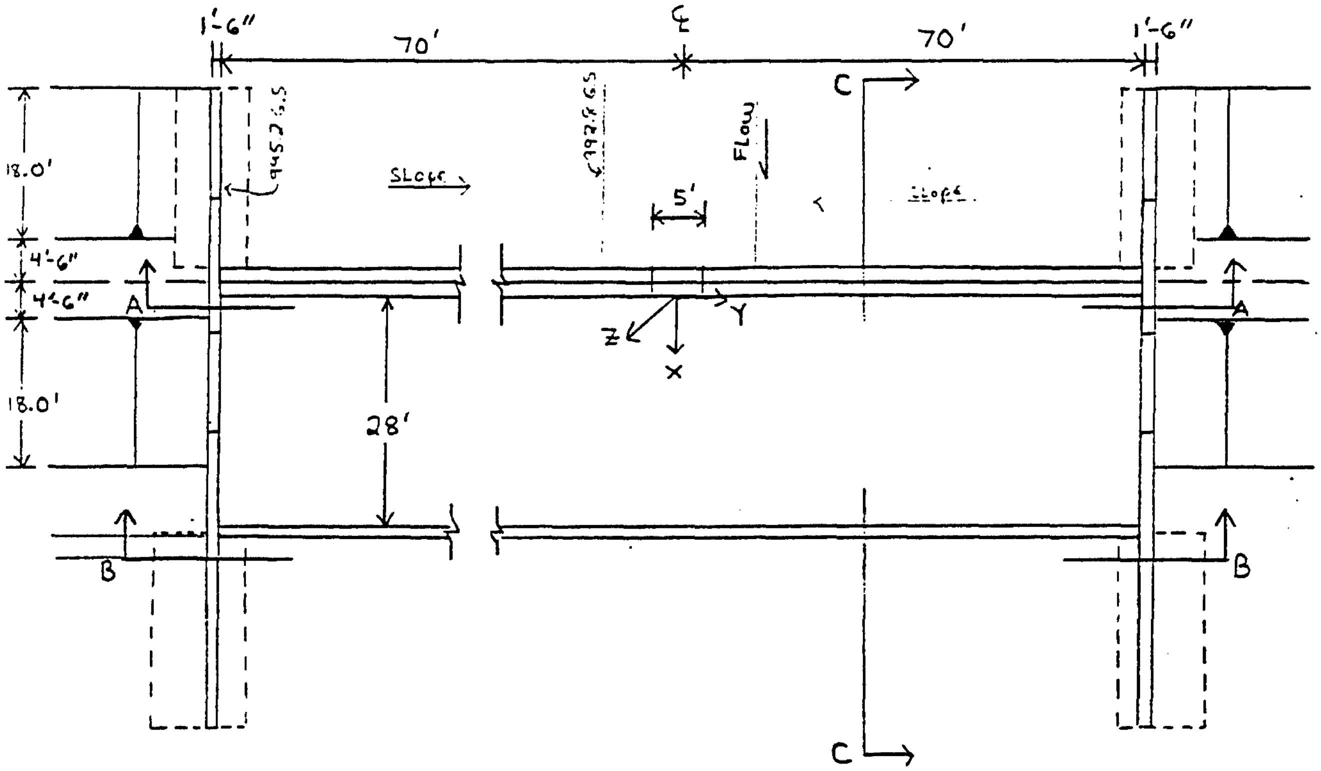
Use #5 @ 12" ($A_s = 0.31\ {}^{in^2}/ft$) E.F. E.W. for temp. & shrinkage.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3-31-92	PAGE 31 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION D/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	



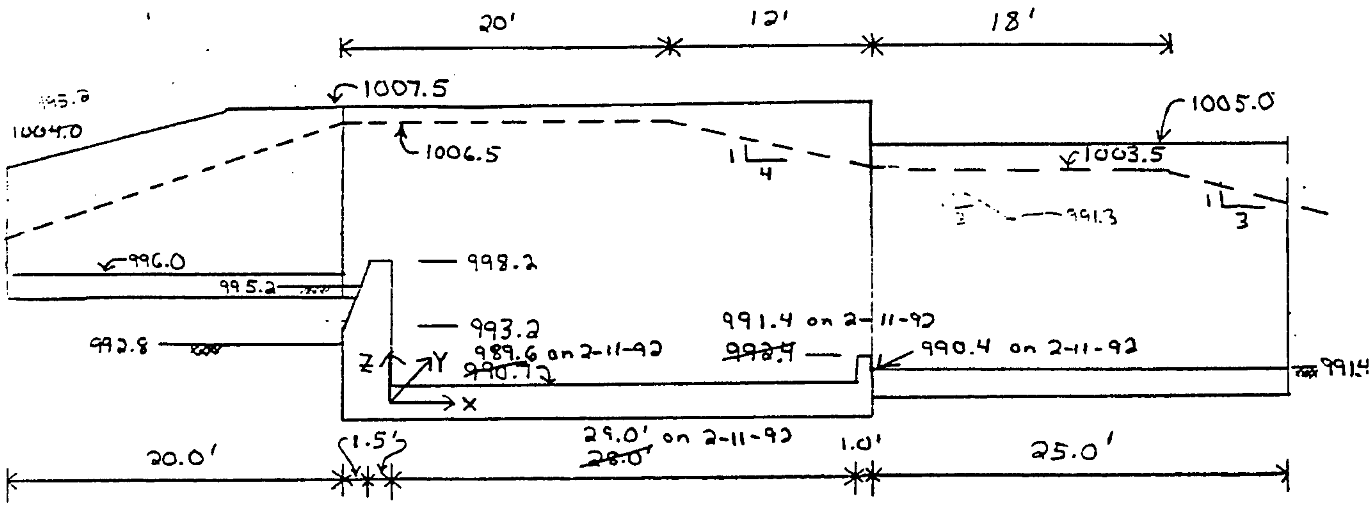
Section B
Scale: 1"=5'-0"

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 3 Dec '91	PAGE 1 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION U/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	



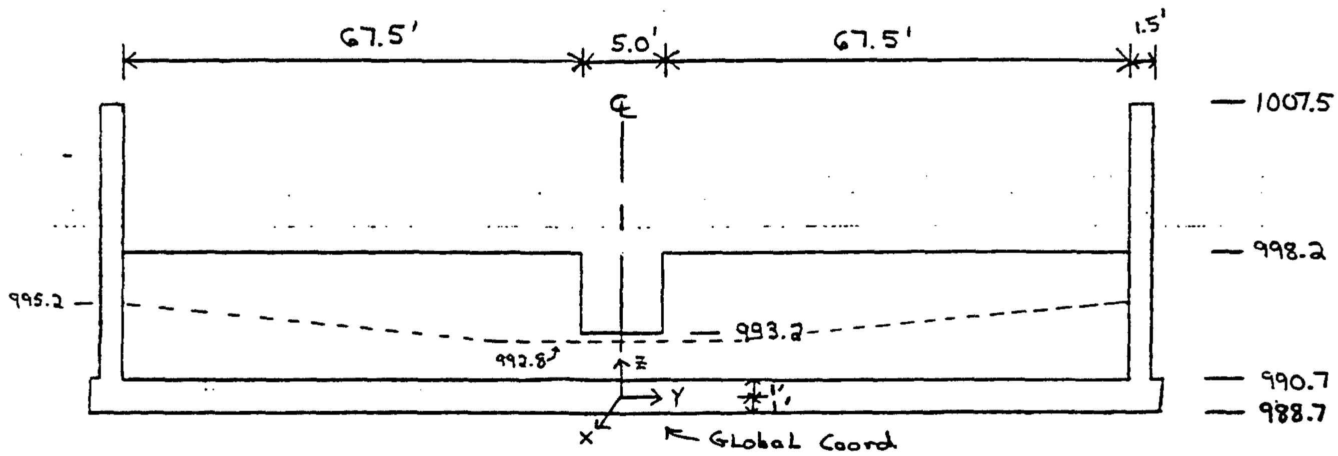
PLAN
Scale: 1"= 20'

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 4 Dec '91	PAGE 2 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION U/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

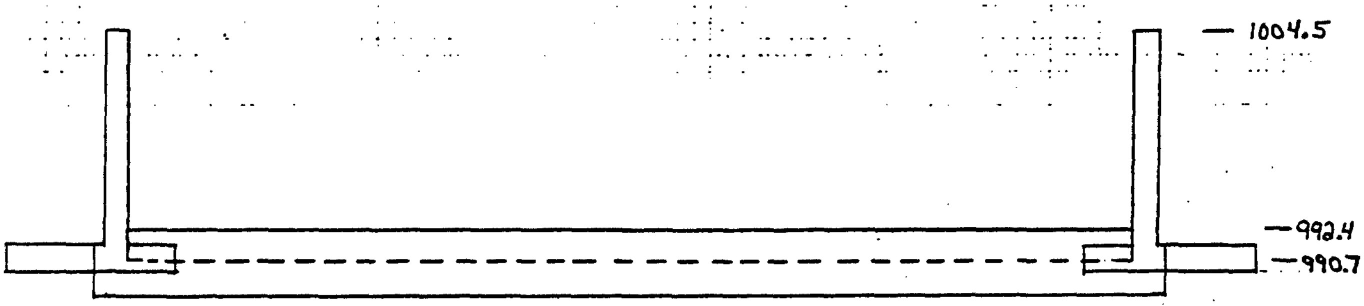


SECTION C-C
Scale: 1"=10.0'

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 9 Dec '91	PAGE 3 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION u/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

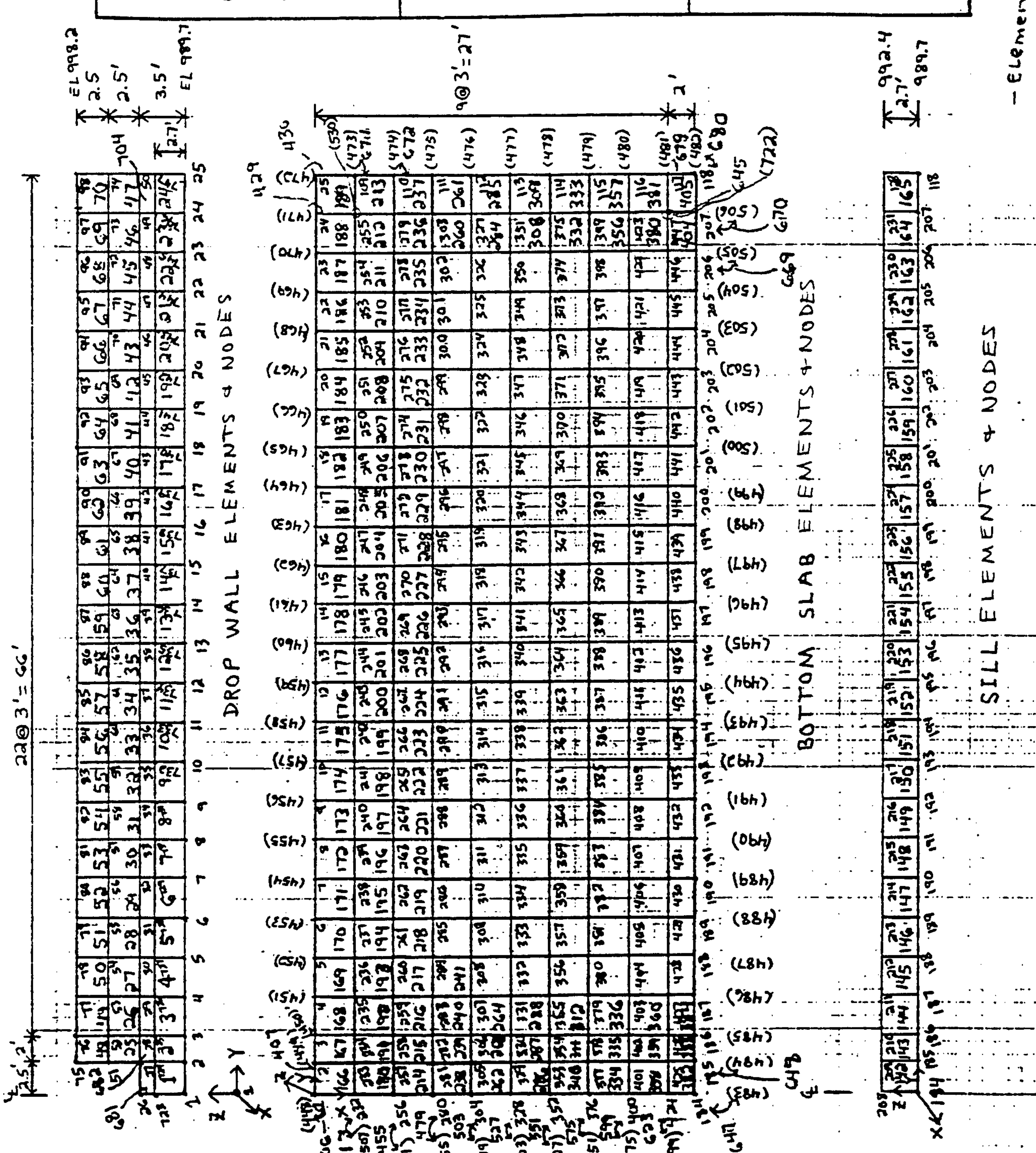


SECTION A-A
N.T.S.

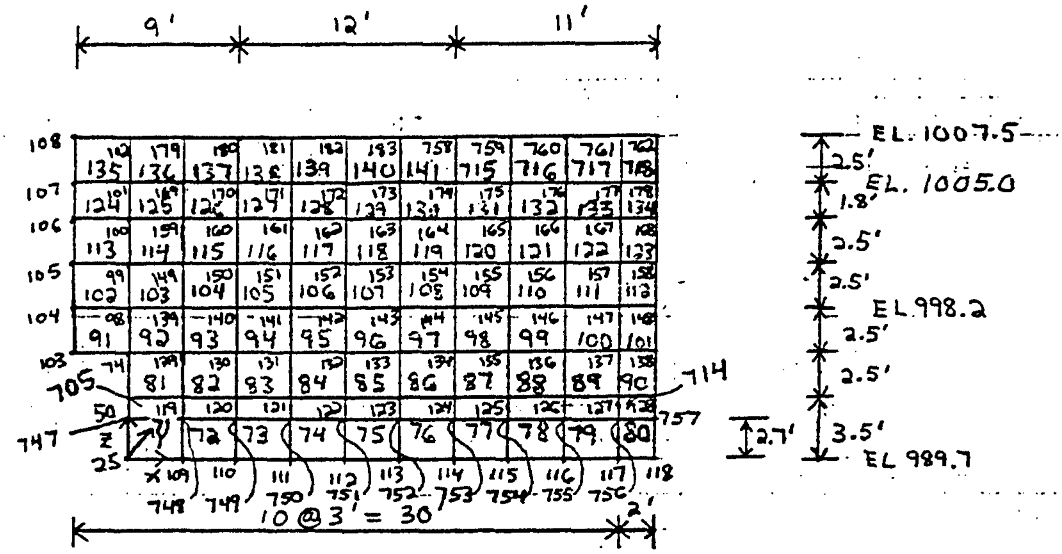


SECTION B-B
N.T.S.

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 13 Dec '91	PAGE 4 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION U/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	



ST. PAUL DISTRICT COMPUTATION SHEET	DATE 13 Dec '91	PAGE 5 OF	FILE NUMBER
NAME OF OFFICE		COMPUTATION U/S Drop Structure	
SUBJECT Rochester Stage 4 FDM		SOURCE DATA	
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	



SIDE WALL ELEMENTS + NODES

ST. PAUL DISTRICT COMPUTATION SHEET	DATE 10 Dec '91	PAGE 5A OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION u/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

Assumptions:

$f_y = 48$ ksi => use Load Factor = 1.9
$f'_c = 4$ ksi

Backfill: (See Geo-Tech memo 11-4-91 & 10-21-91)

$\gamma_{sat} = 125$ lb/ft³
$\gamma_{sub} = 62.5$ lb/ft³
$\gamma_{moist} = 120$ lb/ft³
$\gamma_{water} = 62.5$ lb/ft³
$c = 0$ (cohesion)
$\phi = 26°$ between conc. & soil (for sliding)
= 33° " " & rock
= 33° " " & soil

InSitu Soils:

$\gamma_{sat} = 125$ pcf
$\gamma_{moist} = 115$ pcf
$c = 0$
$\phi = 26°$ between conc. & soil (sliding)
= 33° " " & rock
= 33° " " & soil

Bedrock:

$\gamma = 160$ pcf
$c = 50$ psi = 7.2 ksf
$\phi = 0$
Allowable bearing on bedrock = 12 tsf (167 psi)

Design water surface U/S of Drop Struc. = EL. 1006.3 (Hydr. memo
D/S of Drop Struc. = EL 1002.4 11-20-91)

5yr. water surface U/S of Drop Struc = EL 1002.2
D/S of " " = EL 997.6

✓ NRH 4-5-92

"R4USD"

Prob. name: USD6

DMT
2-11-92
Pg 6

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LNEH 4-8-92

DMT
2-11-92
Pg 7

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✓ NRH
4-8-92

DMT
2-11-92
Pg 8

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~NRH 4-8-92

DMT 2-11-92 Pg 9

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✓NRH
4-8-92

DMT
2-11-92
Pg 10

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note pgs 11-13 are blank

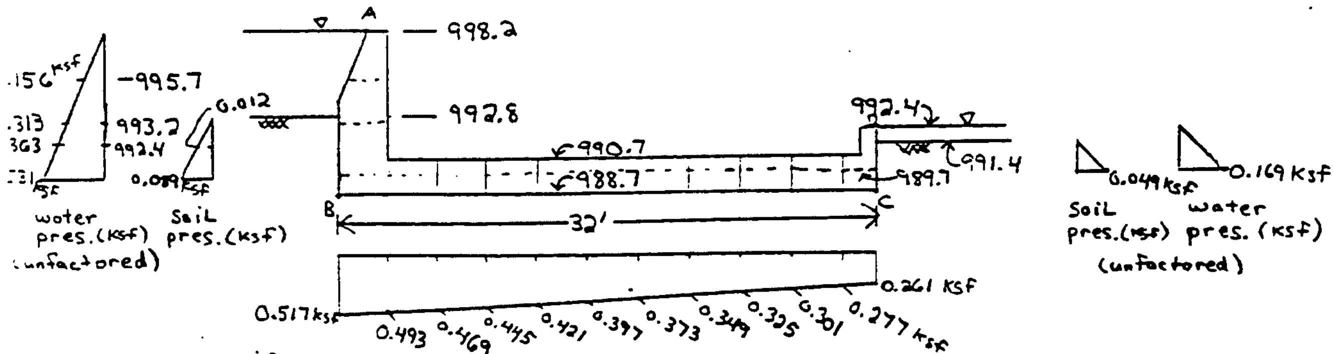
ST. PAUL DISTRICT COMPUTATION SHEET	DATE 11 Dec '91	PAGE 14 OF	FILE NUMBER
NAME OF OFFICE	COMPUTATION U/S Drop Structure		
SUBJECT Rochester Stage 4 FDM	SOURCE DATA Pg 5 D/S calc's		
COMPUTED BY DMT	CHECKED BY NRH 4-8-92	APPROVED BY	

EX = Elastic modulus of conc. = $57{,}000\sqrt{f_c'}$
$= 57{,}000\sqrt{4000}$
$= 3{,}604{,}997$ psi
$= 519{,}120$ ksf

DENS = density of concrete = 0.150 kcf

Calculate Loads on structure due to earth + water: (Revised see pg 21)

Case 1: Normal Case:



Uplift:

$$U_B = \left[\overline{AB} - \Delta h\left(\frac{\overline{AB}}{ABCD}\right)\right]\gamma_w$$

$$= \left[9.5' - 5.8'\left(\frac{9.5'}{45.2'}\right)\right] 0.0624 \text{ kcf} = 0.517 \text{ ksf}$$

$$U_C = \left[9.5' - 5.8'\left(\frac{41.5}{45.2}\right)\right] 0.0624 = 0.261 \text{ ksf}$$

Drop Wall: (revised, see pg 22A)

$\phi_d = \tan^{-1}(2/3 \tan\phi)$, ϕ' = drained internal friction angle

$\phi_d = \tan^{-1}(2/3 \tan 33°) = 23.4°$

$K_a = K_o = 1 - \sin\phi' = 1 - \sin 33° = \underline{0.46 \text{ ksf}}$

note: K_o is used because 3' thick drop wall is unlikely to move.

SUBJECT: Rochester Stage 4 FDM U/S Drop Structure	COMPUTED BY: DMT	DATE: 1-7-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 15

Drop Wall con't)

$\gamma_{sub} = 0.0625$ kcf (See pg 4)

At Elev. 989.7:

$$\text{Pressure} = K_o \gamma_{sub} h_{soil} + \gamma_w h_{water}$$
$$= (0.46)(0.0625\text{ kcf})(3.1') + (0.0625\text{ kcf})(8.5')$$
$$= 0.089 + 0.531$$

Factored Pressure $= 0.620$ ksf $\times 1.9 =$ 1.178 ksf

At Elev. 993.2:

$$\text{Pressure} = \gamma_w h_{water}$$
$$= (0.0625\text{ kcf})(5.0')$$
$$= 0.313\text{ ksf} \times 1.9 = \underline{0.595\text{ ksf}}$$

At Elev 995.7:

$$\text{Pressure} = (0.0625)(2.5)$$
$$= 0.156\text{ ksf} \times 1.9 = \underline{0.296\text{ ksf}}$$

Sill:

At Elev 989.7:

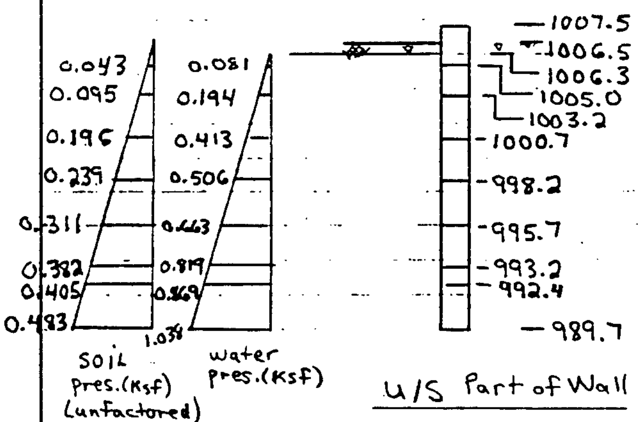
$$\text{Pressure} = (.46)(0.0625)(1.7)_{soil} + (0.0625)(2.7)_{water}$$
$$= 0.049 + 0.169$$
$$= 0.218\text{ ksf} \times 1.9 = \underline{0.414\text{ ksf}}$$

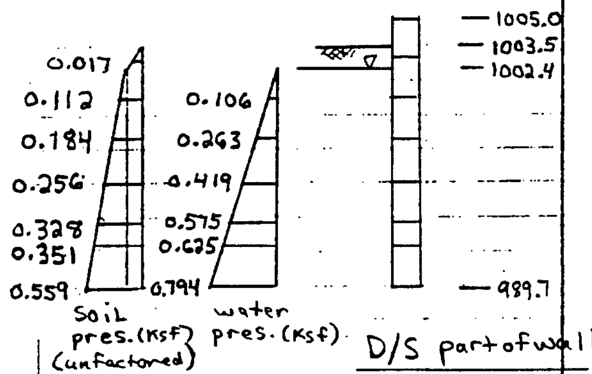
At Elev. 992.4

$$\text{Pressure} = (0.46)(0.0625)(0.4')_{soil} + (0.0625\text{ kcf})(5.8')_{water}$$
$$= 0.012 + 0.363$$
$$= 0.375 \times 1.9 = \underline{0.713\text{ ksf}}$$

SUBJECT: Rochester Stage 4 FDM U/S Drop Structure	COMPUTED BY: DMT	DATE: 1-8-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 16

Side Wall: (See revised pg 23)
Load factor = 1.9 (see pg 4)





U/S Part of Wall

At Elev 992.4
Press = (0.46)(0.0625)(14.1′) + (0.0625)(13.9′)
= 0.405 + 0.869
= 1.274 × 1.9 = 2.421 ksf

At Elev. 989.7 :
Press. = (K_o 0.46)(0.0625)(16.8′) [soil] + (0.0625)(16.6′) [water]
= 0.483 ksf + 1.038 ksf
Fact. Pres. = 1.521 ksf × 1.9 = 2.890 ksf

At Elev 993.2 :
Pres = (.46)(.0625)(13.3) [soil] + (.0625)(13.1) [water]
= 0.382 + 0.819
= 1.201 ksf × 1.9 = 2.282 ksf

At Elev. 995.7 :
Pres. = (.46)(0.0625)(10.8′) [soil] + (.0625)(10.6′) [water]
= 0.311 + 0.663
= 0.974 ksf × 1.9 = 1.851 ksf

At Elev. 998.2 ;
Pres = (0.46)(0.0625)(8.3′) + .0625(8.1′)
= 0.239 + 0.506
= 0.745 ksf × 1.9 = 1.416 ksf

D/S part of wall

At Elev. 992.4
Pres = 0.063 + 0.0625 (10.0′(.46) + 10.0′)
= 0.063 + 0.288 + 0.625
= 0.976 × 1.9 = 1.854 ksf

At Elev. 989.7
Pres = (0.46)(0.125)(1.1′) + (0.0625)(12.7)(.46) [soil] + (.0625)(12.7′) [w]
= 0.063 + 0.365 + 0.794
Fact. Pres = 1.222 ksf × 1.9 = 2.322 ksf

At Elev. 993.2 : soil
Press = 0.063 + 0.0625 (9.2′(.46) + 9.2′)
= 0.063 + 0.265 + 0.575
= 0.903 ksf × 1.9 = 1.716 ksf

At Elev. 995.7 :
Pres = 0.063 + 0.0625 (6.7′(.46) + 6.7′)
= 0.063 + 0.193 + 0.419
= 0.675 ksf × 1.9 = 1.283 ksf

At Elev 998.2 :
Pres. = 0.063 + 0.0625 (4.2′(.46) + 4.2′)
= 0.063 + 0.121 + 0.263
= 0.447 ksf × 1.9 = 0.849 ksf

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 FDM U/S Drop Structure	COMPUTED BY: DMT	DATE: 1-8-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 17

Side wall con't.:

At ELev. 1000.7

Pres = (0.46)(0.0625)(6.8') + 0.0625(6.6') (soil, water)
= 0.196 + 0.413
F.P. = 0.609 ksf × 1.9 = 1.157 ksf

At ELev. 1003.2

Pres = 0.46(0.0625)(3.3') + .0625(3.1')
= 0.095 + 0.194
= 0.289 × 1.9 = 0.549 ksf

At ELev. 1005.0

Pres = 0.46(0.0625)(1.5') + 0.0625(1.3')
= 0.043 + 0.081
= 0.124 × 1.9 = 0.236 ksf

At ELev. 1000.7

Pres. = 0.063 + 0.0625(1.7'(.46) + 1.7')
= 0.063 + 0.049 + 0.106
F.P. = 0.218 × 1.9 = 0.414 ksf

At ELev. 1003.2

Pres. = 0.46(0.125)(0.3')
= 0.017 × 1.9 = 0.033 ksf

ELement Pressures: (Cosmos pg. 11-3)

Drop Wall: (See revised pg 22A)

ELements 1-24:

Factored pressures = $\frac{1.178 + 0.713 \text{ ksf}}{2}$ = 0.945 ksf (.913)
(On outside face)

ELements 25-47:

Factored pressures = $\frac{0.595 + 0.296 \text{ ksf}}{2}$ = 0.446 ksf ✓

ELements 48-70:

Factored pressures = $\frac{0.296 \text{ ksf} + 0}{2}$ = 0.148 ksf ✓

ELements 680-703:

Factored pressures = $\frac{0.713 + 0.595 \text{ ksf}}{2}$ = 0.654 ksf

SUBJECT: Rochester Stage 4 FDM U/S Drop Structure	COMPUTED BY: DMT	DATE: 1-8-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 18

Element Pres. con't.:

Sill:

Elements 142-165

$$\text{Factored Pressure} = \frac{0.414\ \text{ksf} + 0}{2} = 0.207\ \text{ksf}$$

Side Wall: (see revised pg 24)

Elements 71-76:

2.836

$$\text{Factored Pressure} = \frac{2.890 + 2.421\ \text{ksf}}{2} = 2.656\ \text{ksf}$$

Elements 77-80:

2.239

$$\text{Fact. Pres.} = \frac{2.322 + 1.854\ \text{ksf}}{2} = 2.088\ \text{ksf}$$

Elements 81-86:

2.266

$$\text{Fact. Pres.} = \frac{2.282 + 1.851\ \text{ksf}}{2} = 2.066\ \text{ksf}$$

Elements 87-90:

1.669

$$\text{Fact. Pres.} = \frac{1.716 + 1.283\ \text{ksf}}{2} = 1.500\ \text{ksf}$$

Elements 91-97:

1.791

$$\text{Fact. Pres.} = \frac{1.851 + 1.416\ \text{ksf}}{2} = 1.634\ \text{ksf}$$

Elements 98-101:

$$\text{F.P.} = \frac{1.283 + 0.849\ \text{ksf}}{2} = 1.066\ \text{ksf}$$

Elements 102-108:

1.41

$$\text{F.P.} = \frac{1.416 + 1.157\ \text{ksf}}{2} = 1.287\ \text{ksf}$$

Elements 704-709 : Elements 710-713

$$\text{F.P.} = \frac{2.421 + 2.282}{2} = 2.352\ \text{ksf} \qquad \text{F.P.} = \frac{1.854 + 1.716}{2} = 1.785\ \text{ksf}$$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 FDM U/S Drop Structure	COMPUTED BY: DMT	DATE: 1-8-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 19

Element Pressures con't:

Elements 109-112:

.720

$$F.P. = \frac{0.849 + 0.414 \text{ ksf}}{2} = \underline{0.632 \text{ ksf}}$$

Elements 113-119:

.936

$$F.P. = \frac{1.157 + 0.549 \text{ ksf}}{2} = \underline{0.853 \text{ ksf}}$$

Elements 120-123:

.262

$$F.P. = \frac{0.414 + 0.033 \text{ ksf}}{2} = \underline{0.224 \text{ ksf}}$$

Elements 124-130:

.433

$$F.P. = \frac{0.549 + 0.236 \text{ ksf}}{2} = \underline{0.393 \text{ ksf}}$$

Elements 131-134:

0.022

$$F.P. = \frac{0.033 \text{ ksf}}{2} = \underline{0.017 \text{ ksf}}$$

Elements 135-141:

.131

$$F.P. = \frac{0.236 \text{ ksf}}{2} = \underline{0.118 \text{ ksf}}$$

Bottom Slab: (see revised, pg 30)

Elements 166-189

$$\text{Factored Pressure} = \frac{0.493 + 0.469 \text{ ksf}}{2} = 0.481 \times 1.9 = \underline{0.914 \text{ ksf}}$$

Elem. 190-213: $F.P. = \frac{0.469 + 0.445 \text{ ksf}}{2} = 0.457 \times 1.9 = \underline{0.868 \text{ ksf}}$

Elem. 214-237: $F.P. = \frac{0.445 + 0.421 \text{ ksf}}{2} = 0.433 \times 1.9 = \underline{0.823 \text{ ksf}}$

Elem. 238-261: F.P. = 0.409 ksf × 1.9 = <u>0.777 ksf</u>

Elem. 262-285: F.P. = 0.385 ksf × 1.9 = <u>0.732 ksf</u>

Elem. 286-309: F.P. = 0.361 ksf × 1.9 = 0.686 ksf

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 FDM U/S Drop Structure	COMPUTED BY: DMT	DATE: 1-8-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 20

Element pressures Cont:

Elements 310-333: F.P. = 0.337 ksf × 1.9 = 0.640 ksf

Elements 334-357: F.P. = 0.313 ksf × 1.9 = 0.595 ksf

Elements 358-381: F.P. = 0.289 ksf × 1.9 = 0.549 ksf

Elements 382-405: F.P. = 0.269 ksf × 1.9 = 0.511 ksf

WES FORM NO. 1253
REV OCT 1968

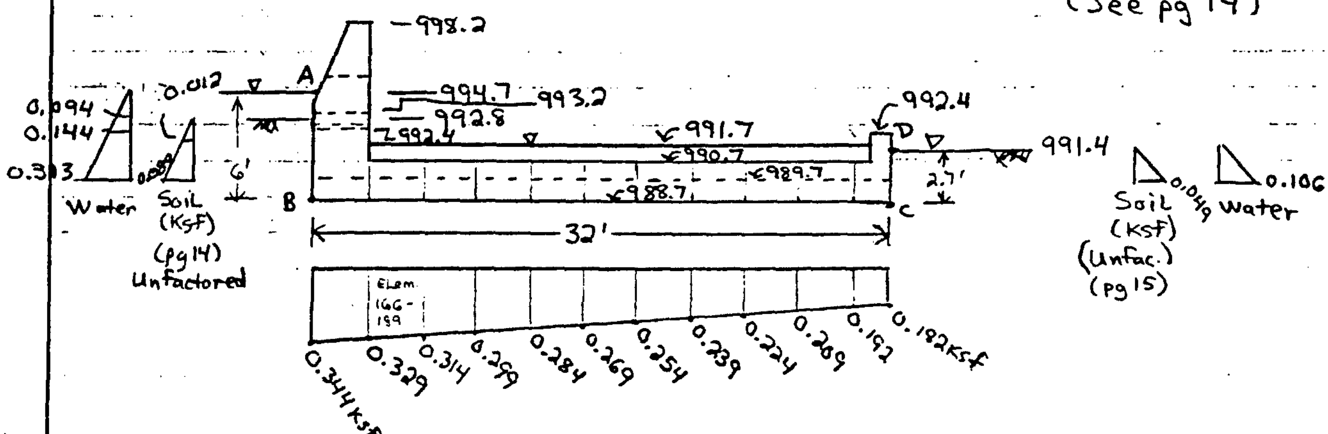
SUBJECT: Rochester Stage 4 DM u/s Drop Structure	COMPUTED BY: DMT	DATE: 1-31-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 21

See GeoTech UpLift CaLc's

Because of seepage control the head on the U/S & D/S can be reduced. Use 6.0' on the U/S (from 9.5' on pg 14) and use 2.7' (from 3.7')

Normal Case:

(See pg 14)



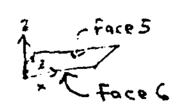
UpLift:

$$u_B = \left[\overline{AB} - \Delta h \left(\frac{\overline{AB}}{\overline{ABCD}} \right) \right] \gamma_w$$

$$= \left[6.0' - 3.3' \left(\frac{6.0'}{40.7'} \right) \right] 0.0624 \text{ kcf} = 0.344 \text{ ksf}$$

$$u_C = \left[6.0 - 3.3 \left(\frac{38.0}{40.7} \right) \right] 0.0624 \text{ kcf} = 0.182 \text{ ksf}$$

Element Pressures on bottom sLab:



ELements 166-189:

Face 6: Factored Pressure $= \frac{0.329 + 0.314 \text{ ksf}}{2} \times 1.9 = 0.611$ ksf on face 6

Face 5: F.P. $= 1' \times 0.0624 \text{ kcf} \times 1.9 =$ 0.119 ksf on face 5

Total F.P. on face 6 = 0.492 ksf

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 DM U/S Drop Structure	COMPUTED BY: DMT	DATE: 1-31-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 22

Elements 190-213:

$$F.P. = \left(\frac{\overset{\text{Face 6}}{0.314} + \overset{\text{Face 5}}{0.299}}{2} - 0.0624\right)1.9 = \underline{0.464 \text{ ksf}}$$

Elements 214-237:

$$F.P. = \left(\frac{0.299+0.284}{2} - 0.0624\right)1.9 = \underline{0.435 \text{ ksf}}$$

Elements 238-261:

$$F.P. = \left(\frac{0.284+0.269}{2} - 0.0624\right)1.9 = \underline{0.407 \text{ ksf}}$$

Elements 262-285:

$$F.P. = \left(\frac{0.269+0.254}{2} - 0.0624\right)1.9 = \underline{0.378 \text{ ksf}}$$

Elements 286-309:

$$F.P. = \left(\frac{0.254+0.239}{2} - 0.0624\right)1.9 = \underline{0.350 \text{ ksf}}$$

Elements 310-333:

$$F.P. = \left(\frac{0.239+0.224}{2} - 0.0624\right)1.9 = \underline{0.331 \text{ ksf}}$$

Elements 334-357:

$$F.P. = \left(\frac{0.224+0.209}{2} - 0.0624\right)1.9 = \underline{0.293 \text{ ksf}}$$

Elements 358-381:

$$F.P. = \left(\frac{0.209+0.192}{2} - 0.0624\right)1.9 = \underline{0.262 \text{ ksf}}$$

Elements 382-405:

$$F.P. = \left(\frac{0.192-0.182}{2} - 0.0624\right)1.9 = \underline{0.237 \text{ ksf}}$$

SUBJECT: Rochester Stage 4 DM U/S Drop Structure	COMPUTED BY: DMT	DATE: 2-5-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 22A

Drop Wall Pressures:

At Elev. 989.7:

$$F.P. = [\overset{soil}{0.089} + \overset{0.313}{5'(0.0625)}]\,1.9 = \underline{0.764 \text{ ksf}}$$

At Elev 992.4:

$$F.P = [0.012 + \overset{0.144}{2.3(.0625)}]\,1.9 = \underline{0.296 \text{ ksf}}$$

At Elev. 993.2

$$F.P = 1.5'(0.0625) \times 1.9 = \underline{0.178 \text{ ksf}}$$

Element Pressures on Drop Wall:

Elements 1-24:

$$F.P. = \frac{0.764 + 0.296}{2} = \underline{0.530 \text{ ksf on face 6}}$$

Elements 681-704:

$$F.P. = \frac{0.296 + 0.178}{2} = \underline{0.237 \text{ ksf}}$$

Elements 25-47:

$$F.P. = \frac{0.178}{2} = \underline{0.089 \text{ ksf}}$$

Sill Pressures:

At Elev. 989.7: $F.P. = [0.049 \text{ ksf} + \overset{0.106}{1.7'(0.0625)}]\,1.9 = \underline{0.295 \text{ ksf}}$

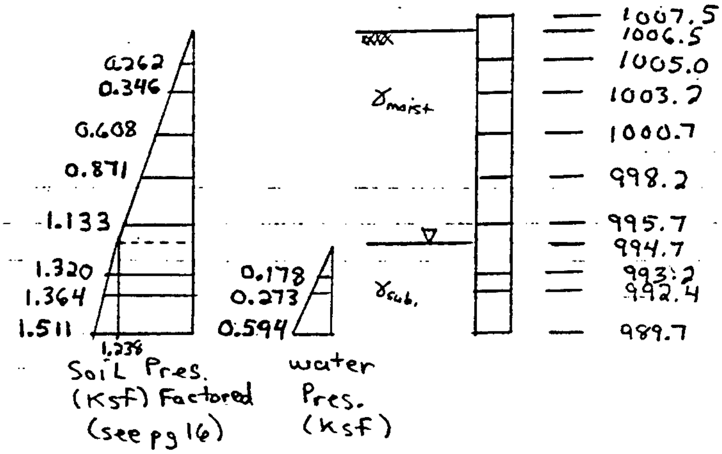
Elem. Press. on Sill:

Elements 142-165: $F.P. = \frac{0.295}{2} = \underline{0.148 \text{ ksf}}$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 DM u/s Drop Structure	COMPUTED BY: DMT	DATE: 2-11-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 23

Reduce the water head on the side wall (see pg 21 for explanation)



At Elev. 1005.0

$$\text{Fact. Pres.} = 1.9\left[(\overset{K_a}{.46})(\overset{\gamma_{moist}}{0.120})(2.5') + \overset{water}{0}\right] = \underline{0.262 \text{ ksf}}$$

At Elev. 1003.2

$$F.P. = 1.9\left[\overbrace{(0.46)(.120)}^{0.0552}(3.3') + 0\right] = \underline{0.346 \text{ ksf}}$$

At Elev. 1000.7

$$F.P. = 1.9\left[(0.0552)(5.8') + 0\right] = \underline{0.608 \text{ ksf}}$$

At Elev. 998.2

$$F.P. = 1.9\left[(0.0552)(8.3') + 0\right] = \underline{0.871 \text{ ksf}}$$

At Elev. 995.7

$$F.P. = 1.9\left[(0.0552)(10.8') + 0\right] = \underline{1.133 \text{ ksf}}$$

At Elev. 993.2

$$F.P. = 1.9\left[(0.46)(\overset{\gamma_{moist}}{.120})(11.8') + (0.46)(\overset{\gamma_{sub.}}{0.0625})(1.5') + (\overset{\gamma_{water}}{0.0625})(1.5')\right]$$

$$= \underline{1.498 \text{ ksf}}$$

SUBJECT: Rochester Stage 4 DM u/S Drop Structure	COMPUTED BY: DMT	DATE: 2-11-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 24

At ELev. 992.4

$$F.P. = 1.9\left[(0.46)(0.0625)(2.3') + (0.0625)(2.3')\right] + 1.238 = \underline{1.637\text{ ksf}}$$

At ELev. 989.7 :

$$F.P. = 1.9\left[(0.46)(0.0625)(5.0') + (0.0625)(5.0')\right] + 1.238 = \underline{2.105\text{ ksf}}$$

Element Pressures for Side Wall :

ELem. 71-80 : $F.P. = \frac{2.105 + 1.637}{2} = \underline{1.871\text{ ksf}}$

ELem. 705-714 : $F.P. = \frac{1.637 + 1.498}{2} = \underline{1.568\text{ ksf}}$

ELem 81-90 : $F.P. = \frac{1.498 + 1.133}{2} = \underline{1.316\text{ ksf}}$

ELem 91-101 : $F.P. = \frac{1.133 + 0.871}{2} = \underline{1.002\text{ ksf}}$

ELem. 102-112 : $F.P. = \frac{0.871 + 0.608}{2} = \underline{0.740\text{ ksf}}$

ELem. 113-123 : $F.P. = \frac{0.608 + 0.346}{2} = \underline{0.477\text{ ksf}}$

ELem 124-134 : $F.P. = \frac{0.346 + 0.262}{2} = \underline{0.304\text{ ksf}}$

ELem. 135-141, 715-718 : $F.P. = \frac{0.262}{2} = \underline{0.131\text{ ksf}}$

SUBJECT: Rochester Stage 4 DM U/S Drop Structure	COMPUTED BY: DMT	DATE: 2-6-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 25

Design the reinforcement for the side wall, drop wall, sill, and bottom slab from the results of COSMOS & OUTCON

1) Reinforcement in the side wall : (See plot of side wall stresses pg.)

Find the maximum reinforcement and shear ratio (VXRAT & VYRAT) in each row & column.

Row	ASX Horz. Rein. (in²/ft)		VXRAT Shear ratio in Horz. direction	
elem. 71 - 80	0.22	(Ele.77)	0.21	(Ele.72)
elem 705 - 714	0.20	(Ele.705)	0.69	(Ele.714)
elem. 81 - 90	0.31	(Ele.81)	0.38	(Ele. 90)
elem. 91 - 101	0.42	(Ele. 92)	0.66	(Ele. 92)
elem. 102 - 112	0.36	(Ele. 103)	0.64	(Ele. 103)
elem. 113 - 123	0.20	(Ele. 114)	0.17	(Ele. 115)
elem. 124 - 134	0.21	(Ele. 130)	0.16	(Ele. 126)
elem. 135-141, 715-718	0.22	(Ele. 141)	0.20	(Ele. 138)

Column	ASY vert. Rein. (in²/ft.)		VYRAT Shear ratio in vert. direction	
elem. 91, 102 ··· 135	0.56	(Ele. 102)	0.95	(Ele. 91)
elem. 71 ··· 136	0.65	(Ele. 92)	0.72	(Ele. 103)
elem. 72 ··· 137	0.31	(Ele. 93)	0.14	(Ele. 72)
elem. 73 ··· 138	0.21	(Ele. 73)	0.40	(Ele. 73)
elem. 74 ··· 139	0.59	(Ele. 74)	0.55	(Ele. 74)
elem. 75 ··· 140	0.80	(Ele. 75)	0.62	(Ele. 75)
elem. 76 ··· 141	0.80	(Ele. 76)	0.65	(Ele. 76)
elem. 77 ··· 131	0.84	(Ele. 77)	0.66	(Ele 77)
elem. 78 ··· 132	0.89	(Ele. 78)	0.62	(Ele. 78)
elem. 79 ··· 133	0.82	(Ele. 79)	0.28	(Ele. 89)
elem 80 ··· 134	0.68	(Ele. 90)	0.83	(Ele. 90)

Temp. & shrinkage

$$A_s = 0.0018 \cdot b \cdot h \qquad (\tfrac{1}{2} \text{ in each face})$$
$$= 0.0018(12'')18''$$
$$= 0.39 \ in^2/ft$$

$A_s = 0.20 \ in^2/ft$ in each face < max $ASX = 0.42 \ in^2/ft$

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 DM U/S Drop Structure	COMPUTED BY: DMT	DATE: 2-6-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO 26

Vertical Flexural rein.:

Landside: max. ASY = 0.84 in element 77 & 78

∴ use #6 @ 6" ($A_s = 0.88$ in²/ft) for 11 ft above slab

& use #6 @ 12" ($A_s = 0.44$ in²/ft) for remainder

Channel side: Use #5 @ 12" ($A_s = 0.31$ in²/ft)

Horizontal Flexural Rein. max ASX = 0.42 in²/ft

Land & Channel side:

use #6 @ 12" ($A_s = 0.44$ in²/ft)

Check Ductility: $\rho_{min} < \rho < \rho_{max}$

$$\rho_{min} = \frac{200}{f_y} = 0.0042$$

$$\rho_{max} = 0.0097 \quad \text{for } f'_c = 4 \text{ Ksi} \quad (\text{ETL 1110-2-265})$$

$$\rho = \frac{A_s}{bd} = \frac{0.88}{(12)(15)} = 0.0049 \quad \therefore \text{OK}$$

2. Reinforcement in the Drop Wall:

Row	ASX - Horz. Rein. (in²/ft)	VXRAT - Shear ratio in Horz. direction
eL. 1-24	0.77 (EL.2)**	0.14 (EL. 24)
eL. 681-704	1.39 (EL.682)*	0.17 (EL 682)
eL. 25-47	0.74 (EL.25)	0.21 (EL. 47)
eL. 48-70	0.37 (EL 51)	0.05 (EL 68)

** - ignore ASX for EL 1, see *

* ignore ASX for Elem. 681, Large axial forces ($NX = 484^k$) caused by constraints on node 26 & 723

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 DM u/S Drop Structure	COMPUTED BY: DMT	DATE: 2-7-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO 27

Drop Wall Con't: Column	ASY - Vert. Rein. (in^2/ft)	VYRAT - Shear ratio in horz. direc.
EL. 1, 681	0.49 (EL. 681)	0.24 (EL. 681)
EL 2 ·· 48	0.34 (EL. 25)	0.05 (EL 25)
EL 3 ·· 49	0.01 (EL. 49)	0.02 (EL 49)
EL. 4 ·· 50	0	0.02 (EL. 4)
EL 5 ·· 51	0	0.02 (EL. 5)
EL 6 ·· 52	0	0.02 (EL. 6)
EL. 7 ·· 53	0	0.02 (EL. 7)
EL 8 ·· 54	0	0.02 (EL 8)
EL 9 ·· 55	0	0.02 (EL. 9)
EL. 10 ·· 56	0	0.02 (EL 10)
⋮		
E 24 ·· 70	0.07 (EL. 24)	0.07 (EL 24)

Temp. & Shrinkage:

$A_s = 0.0018\,(12'')(36'') = 0.78\ in^2/ft$

$\frac{1}{2}A_s = 0.39\ in^2/ft$. in each face < max. ASX = $1.39\ in^2/ft$.
> max. ASX for elements 686 - 704

Vertical Flexural Rein:

Landside: use ASY = $0.49\ in^2/ft$.

∴ Use ~~#6 @ 12''~~ ($A_s = 0.44\ in^2/ft$) ⇒ use #8 @ 6'' See Duct. pg 28

Channel side: ($0.39\ in^2/ft$ T. & S.)

∴ Use #6 @ 12'' ($A_s = 0.45\ in^2/ft$)

Note: more rein. will be required around cut-out at ℄ & at connection to side wall.

Horiz. Rein: Use ASX = $1.39\ in^2/ft$

Landside: use #8 @ 6'' ($A_s = 1.57\ in^2/ft$) for 10' from ℄
use #7 @ 6'' ($A_s = 1.20\ in^2/ft$) for beyond

Channel side: Use #6 @ 12'' ($A_s = 0.45\ in^2/ft$)

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 DM U/S Drop Structure	COMPUTED BY: DMT	DATE: 2-10-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO 28

Drop wall Con't

Check Ductility

$$\rho = \frac{0.44}{(12)(33)} = 0.0011 < \rho_{min} = 0.0042$$

$$\Rightarrow A_s = (0.0042)(12'')(33'') = 1.66 \ in^2/ft$$

$\therefore$ Use #8 @ 6" ($A_s = 1.57\ in^2/ft$) for vert. rein. on Landside

3. Sill Reinforcement

use ASX = 0.46 in^2/ft (EL 142)
" ASY = 0.04 in^2/ft (EL 143)

Vert. rein.: Use #6@12" ($A_s = 0.44\ in^2/ft$) on both sides

Horiz rein; use #6@ 12" on both sides

Ductility: $\frac{0.44}{(12)(9'')} = 0.0041 \approx \rho_{min}$ $\therefore$ OK

4. Slab Reinforcement:

Max. ASX (Transverse) = 0.22 in^2/ft

Max ASY (Long.) = 0.46 in^2/ft (near side wall)

Temp. & shrinkage:

$$A_s = (0.0018)(12'')(21'') = 0.52 \ in^2/ft$$

$\therefore$ Use #7 @ 12" ($A_s = 0.60\ in^2/ft$) in Trans. & Long. both top & bottom, (with additional rein. along drop wall)

~

Max, VXRAT = 0.30 (EL. 166)

Max. VYRAT = 0.29 (EL 382)

WES FORM NO. 1253 REV OCT 1968

SUBJECT: Rochester Stage 4 DM U/S Drop Structure	COMPUTED BY: DMT	DATE: 2-10-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 29

5. Shear Reinforcement Design:

Shear ratio from OUTCON = $\frac{VX}{.85VNX}$ = RATIO

VX = Shear from Cosmos
VNX = Allowable shear ($V_c + V_s$)

∴ Since RATIO (both VXRAT & VYRAT) < 1.0 for all elements, except element 91 where VYRAT = 0.95, no shear reinforcement is needed.

SUBJECT: Rochester Stage 4 DM u/S Drop Structure	COMPUTED BY: DMT	DATE: 2-11-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 30

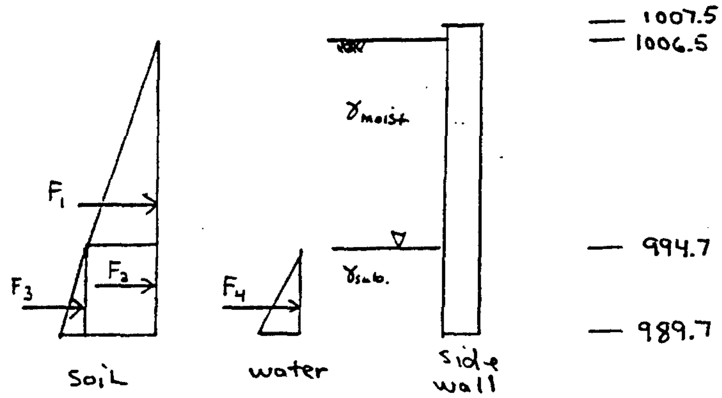
Check Cosmos Design results:

$F.S. = 1.9$ (See pg 4 assumptions)

$F_y = 48$ Ksi

$f_c' = 4$ ksi

Check side wall as cantiLever: (see pg 23)



$$F = 1.9\left(\tfrac{1}{2}\cdot K_a \cdot \gamma \cdot H^2\right)$$

$$F_1 = 1.9 \times \tfrac{1}{2} \times (0.46)(0.120\ kcf)(11.8')^2 = 7.3^k$$

$$M_1 = 7.3^k \times 8.9' = \underline{65.0'^k}$$

$$F_2 = 1.9 \times \gamma_{moist} \times H_1 \times H_2 \times k_a$$

$$= 1.9 \times (0.120)(11.8')(5.0')(0.46) = 6.2^k$$

$$M_2 = 6.2^k \times 2.5' = \underline{15.5'^k}$$

$$F_3 = 1.9 \times \tfrac{1}{2} \times 0.46 \times (0.0625)(5.0')^2 = 0.7^k$$

$$M_3 = 0.7^k \times 1.67' = \underline{1.2'^k}$$

SUBJECT: Rochester Stage 4 DM U/S Drop Structure	COMPUTED BY: DMT	DATE: 2-12-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 31

$$F_4 = 1.9 \times \tfrac{1}{2}(0.0625)(5.0')^2 = 1.5^K$$

$$M_4 = 1.5^K \times 1.67' = \underline{2.5'^K}$$

$$\therefore M = 65.0'^K + 15.5'^K + 1.2'^K + 2.5'^K = \underline{84.2'^K}$$

Moment from computer run $= \underset{MY}{47.9'^K} + \underset{\frac{1}{2}\text{ element depth}}{1.35'} \times \underset{VY}{12.6^K}$ (See element

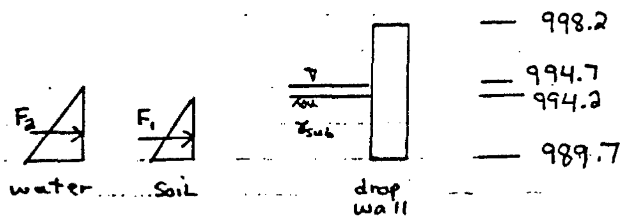
$= \underline{64.9'^K}$

$64.9'^K < 84.2'^K$ because the side wall is not acting as a pure cantilever, but more like a plate with the bottom fully constrainted by the slab & the ends partially constrainted by the drop wall & sill.

WES FORM NO. 1253
REV OCT 1968

SUBJECT: Rochester Stage 4 DM u/S Drop Structure	COMPUTED BY: DMT	DATE: 2-12-92	FILE NO.
	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 32

Check Drop Wall as a cantiLever :



$$F_1 = 1.9 \times \tfrac{1}{2}(0.46)(0.0625\,kcf)(4.5')^2 = 0.55^K$$

$$M_1 = 0.55^K \times 1.50' = \underline{0.8'^K}$$

$$F_2 = 1.9 \times \tfrac{1}{2}(0.0625)(5.0')^2 = 1.48^K$$

$$M_2 = 1.48^K \times 1.67' = \underline{2.47'^K}$$

$$\therefore M = 0.8'^K + 2.47'^K = 3.27'^K$$

Moment from computer run $= 5.72'^K + 1.35' \times 1.71^K$ (eLem. 11)
$= 8.0'^K > M = 3.27'^K \Rightarrow$ program is conservative.

WES FORM NO. 1253
REV OCT 1968

SUBJECT:	COMPUTED BY: DMT	DATE: 2-12-92	FILE NO.
Rochester Stage 4 DM u/s Drop Structure	CHECKED BY: NRH	DATE: 4-8-92	SHEET NO. 33

Check Sliding Stability

$$\overset{\Sigma H}{T} \le \frac{\overset{\Sigma V}{N'} \tan\phi}{F.S.}$$

Use $\phi = 26°$ (pg 4)

F.S. = 1.5 (for normal case)

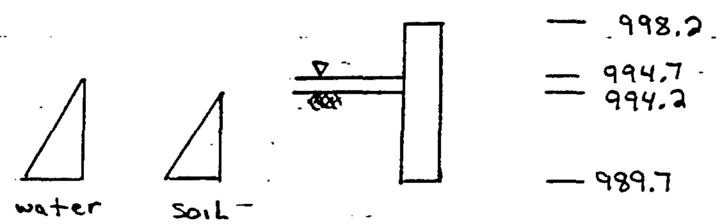
wt. of slab = 146' × 32' × 2' × 0.150 kcf = 1,401.6^k

wt. of drop wall = 2.5' (ht) × 140' × 3.0' (th) × 0.150 kcf = 157.5
+ 1.5' × 5' × 140' × 0.150 = 157.5
+ ½ × 1.5' × 5' × 140' × 0.150 = 78.8
− 5.0' × 5.0' × 1.5' × 0.150 = − 5.6
− ½ × 5.0 × 5.0 × 1.5' × 0.150 = − 2.8

wt. of Sill = 1.7' × 1.0' × 140' × 0.150 = 35.7

wt. of side walls = 2 × 32' × 16.8' × 1.5' × 0.150 = 241.9

$N' = 2,064.6^k$



Soil pressure = ½ (0.46)(0.0625 kcf)(4.5')^2 (140') (width) = 40.8^k
water pressure = ½ (0.0625 kcf)(5.0')^2 (140') = 109.4^k

150.2^k

$$\therefore 150.2^k \le \frac{2064.6^k \tan 26°}{1.5} = 671.3^k \quad \therefore OK$$

WES FORM NO. 1253
REV OCT 1968

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
1	-6.12	-13.1	-5.77	-1.42	5.06	112	1.56	-26.3	36.1	-1.22	0.13	0.07	0.12
2	-3.59	-9.73	-3.54	-1.91	0.656	70.6	0.258	-50	35.9	-0.77	0.09	0.07	0.02
3	-2.97	-8.16	-4.68	-2.09	1.28	37.5	-14.1	-34.3	36	-0.42	0	0.06	0.02
4	-2.64	-7.03	-5.4	-2.32	1.63	19.3	-11.1	-18.4	36	-0.23	0	0.06	0.02
5	-2.42	-6.27	-5.91	-2.54	1.64	12.3	-7.37	-10.9	36	-0.15	0	0.06	0.02
6	-2.27	-5.84	-6.34	-2.76	1.61	9.27	-5.82	-8.17	36.1	-0.12	0	0.07	0.02
7	-2.2	-5.68	-6.74	-2.96	1.62	7.62	-5.38	-7.36	36	-0.1	0	0.07	0.02
8	-2.19	-5.67	-7.15	-3.14	1.65	6.36	-5.33	-7.25	36	-0.09	0	0.08	0.02
9	-2.21	-5.72	-7.56	-3.31	1.68	5.21	-5.37	-7.38	36	-0.07	0	0.08	0.02
10	-2.21	-5.74	-7.97	-3.46	1.7	4.06	-5.42	-7.63	36	-0.06	0	0.08	0.02
11	-2.18	-5.72	-8.38	-3.61	1.71	2.88	-5.47	-7.93	36	-0.05	0	0.09	0.02
12	-2.1	-5.62	-8.77	-3.74	1.71	1.66	-5.51	-8.28	36	0.04	0	0.09	0.02
13	-1.95	-5.4	-9.1	-3.83	1.69	0.4	-5.54	-8.64	36	0.02	0	0.09	0.02
14	-1.71	-5.03	-9.34	-3.88	1.67	-0.912	-5.55	-9.01	36	0	0	0.1	0.02
15	-1.33	-4.45	-9.44	-3.86	1.62	-2.27	-5.53	-9.36	36	0	0	0.05	0.02
16	-0.791	-3.59	-9.34	-3.75	1.55	-3.66	-5.48	-9.66	36	0	0	0.05	0.02
17	-0.0422	-2.32	-8.94	-3.53	1.41	-5.07	-5.35	-9.86	36	0	0	0.05	0.02
18	0.936	-0.522	-8.17	-3.17	1.18	-6.47	-5.13	-9.89	36	0	0	0.04	0.02
19	2.09	1.95	-6.98	-2.71	0.773	-7.83	-4.75	-9.64	36	0	0	0.04	0.01
20	3.18	5.15	-5.45	-2.3	0.0456	-9.07	-4.25	-8.86	36.1	0	0	0.03	0
21	3.48	8.84	-4.03	-2.29	-1.19	-9.98	-3.95	-6.99	36.1	0	0.03	0.03	0.03
22	1.54	11.9	-4.09	-3.38	-3.16	-9.38	-4.25	-2.64	36	0	0.05	0.04	0.08
23	-3.47	11	-8.74	-5.76	-5.87	-4.84	-2.98	6.23	36	0	0.06	0.08	0.14
24	-6.11	6.79	-12.9	-5.8	2.89	-1.19	0.685	15.2	36	0.04	0.07	0.14	0.07
25	-2.48	-5.43	-3.24	1.77	1.66	68.3	26.9	36.5	31.5	-0.74	-0.34	0.08	0.05
26	-1.95	-3.28	-3.75	1.23	1.17	53.7	-11.4	16.6	31.6	-0.58	0	0.05	0.02
27	-1.7	-2.4	-4.42	1.27	0.796	40.4	-11	3.75	31.6	-0.44	0	0.04	0.01
28	-1.48	-1.93	-5.04	1.36	0.654	33.9	-5.75	-1.61	31.5	-0.37	0	0.05	0.01
29	-1.31	-1.7	-5.54	1.43	0.607	29.9	-3.31	-3.55	31.5	-0.33	0	0.05	0.01
30	-1.22	-1.6	-5.96	1.49	0.597	26.6	-2.55	-4.21	31.5	-0.29	0	0.05	0.01
31	-1.18	-1.57	-6.34	1.56	0.601	23.4	-2.38	-4.49	31.4	-0.26	0	0.05	0.01
32	-1.18	-1.57	-6.7	1.65	0.608	20.1	-2.35	-4.68	31.5	-0.22	0	0.05	0.01
33	-1.17	-1.57	-7.06	1.74	0.612	16.7	-2.36	-4.87	31.4	-0.19	0	0.05	0.01
34	-1.14	-1.55	-7.4	1.84	0.611	13.1	-2.37	-5.08	31.5	-0.15	0	0.05	0.01
35	-1.05	-1.51	-7.71	1.94	0.603	9.42	-2.38	-5.3	31.4	-0.11	0	0.06	0.01
36	-0.901	-1.43	-7.97	2.04	0.586	5.54	-2.39	-5.55	31.4	-0.07	0	0.06	0.01
37	-0.657	-1.3	-8.15	2.13	0.555	1.49	-2.4	-5.79	31.5	-0.02	0	0.06	0.01
38	-0.288	-1.1	-8.19	2.2	0.507	-2.74	-2.4	-6.03	31.5	0	0	0.03	0.01
39	0.241	-0.797	-8.03	2.24	0.431	-7.13	-2.38	-6.24	31.4	0	0	0.03	0.01
40	0.96	-0.354	-7.6	2.24	0.315	-11.7	-2.36	-6.4	31.5	0	0	0.03	0
41	1.87	0.278	-6.82	2.15	0.138	-16.3	-2.3	-6.47	31.5	0	0	0.03	0
42	2.87	1.15	-5.65	1.92	-0.129	-20.9	-2.2	-6.35	31.5	0	0	0.03	0
43	3.59	2.32	-4.12	1.46	-0.533	-25.5	-2.14	-5.98	31.5	0	0	0.02	0.02

✓ NRH
4-8-92

P. 34

D-86

ELEMENT	MX	MY	MXY	VX	VY-	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
44	3.08	3.78	-2.61	0.622	-1.17	-29.6	-2.65	-5.32	31.5	0	0.01	0.01	0.03
45	-0.87	5.26	-2.38	-0.802	-2.44	-32.4	-5.81	-4.75	31.5	0	0	0.01	0.04
46	-13.5	5.19	-7.53	-3.52	-5.53	-28.9	-15.3	-4.68	31.5	0	0	0.05	0.08
47	-40.9	-6.09	-20.9	-7.5	1.62	1.22	2.79	7.82	31.5	0.42	0.09	0.21	0.04
48	-0.218	-0.669	-0.473	-0.0202	0.52	1.62	0.303	2.82	22.5	-0.02	0.01	0	0.02
49	-0.866	-0.727	-1.08	0.819	0.516	21.5	0.301	8.88	22.5	-0.24	0.01	0.04	0.02
50	-0.84	-0.559	-1.47	1.17	0.317	32.6	-1.86	3.92	22.6	-0.35	0	0.06	0.01
51	-0.688	-0.426	-1.76	1.33	0.257	34.3	-1.33	0.44	22.5	-0.37	0	0.07	0.01
52	-0.577	-0.362	-1.97	1.43	0.239	32.4	-0.863	-0.92	22.5	-0.35	0	0.07	0.01
53	-0.517	-0.336	-2.13	1.52	0.234	29.4	-0.707	-1.39	22.5	-0.31	0	0.08	0.01
54	-0.494	-0.326	-2.27	1.61	0.233	26	-0.665	-1.57	22.6	-0.28	0	0.08	0.01
55	-0.487	-0.325	-2.41	1.69	0.233	22.5	-0.655	-1.68	22.4	-0.24	0	0.08	0.01
56	-0.48	-0.324	-2.53	1.79	0.234	18.8	-0.652	-1.76	22.5	-0.2	0	0.08	0.01
57	-0.461	-0.322	-2.66	1.88	0.232	15	-0.652	-1.84	22.5	-0.16	0	0.08	0.01
58	-0.419	-0.316	-2.77	1.97	0.228	11	-0.652	-1.93	22.5	-0.12	0	0.09	0.01
59	-0.344	-0.303	-2.86	2.05	0.22	6.75	-0.653	-2.02	22.5	-0.08	0	0.09	0
60	-0.222	-0.281	-2.92	2.11	0.206	2.32	-0.654	-2.11	22.4	-0.03	0	0.09	0
61	-0.0394	-0.245	-2.93	2.15	0.185	-2.31	-0.654	-2.19	22.5	0	0	0.05	0
62	0.222	-0.191	-2.87	2.14	0.152	-7.14	-0.655	-2.27	22.5	0	0	0.05	0
63	0.576	-0.111	-2.71	2.06	0.104	-12.2	-0.655	-2.33	22.5	0	0	0.04	0
64	1.02	0.00733	-2.41	1.88	0.0302	-17.3	-0.655	-2.35	22.5	0	0	0.04	0
65	1.5	0.182	-1.94	1.54	-0.081	-22.6	-0.653	-2.3	22.5	0	0	0.03	0
66	1.84	0.445	-1.29	0.966	-0.258	-27.7	-0.662	-2.18	22.5	0	0	0.02	0.01
67	1.53	0.863	-0.554	0.0107	-0.564	-32.6	-0.757	-2.1	22.5	0	0	0	0.02
68	-0.804	1.53	-0.153	-1.63	-1.11	-37.9	-1.39	-2.83	22.5	0	0.01	0.03	0.05
69	-9.12	2.18	-1.75	-4.77	-1.76	-47.1	-5.69	-7.39	22.5	0	0	0.09	0.04
70	-36	-6.78	-11.5	-12.4	0.42	-71.3	-23.5	-24.7	22.5	0	0	0.23	0.01
71	-5.92	-6.92	-5.98	-3.18	-3.76	-1.56	-2.57	8.12	18	0.09	0.1	0.17	0.2
72	-5.4	-16.7	-8.87	-3.95	2.56	-1.67	-6.79	3.36	18	0.08	0.24	0.21	0.14
73	-7.09	-27.3	-8.23	-3.87	7.49	-1.98	-8.6	1.38	18	0.11	0.43	0.21	0.4
74	-9.39	-35.8	-6.58	-3.29	10.3	-2.17	-9.12	0.52	18	0.15	0.59	0.18	0.55
75	-11.3	-41.8	-4.86	-2.55	11.8	-2.24	-9.13	0.175	18	0.19	0.71	0.14	0.62
76	-12.5	-45.8	-3.22	-1.76	12.4	-2.22	-9.06	0.0745	18	0.21	0.8	0.1	0.65
77	-12.9	-47.9	-1.45	-0.843	12.6	-2.04	-9.15	0.00638	18	0.22	0.84	0.05	0.66
78	-11.8	-48	1.12	0.588	11.8	-1.31	-9.12	-0.435	18	0.21	0.84	0.03	0.62
79	-8.13	-45.1	5.46	2.98	4.88	1.63	-5.09	-2.22	18	0.17	0.82	0.16	0.26
80	-2.89	-34.2	12.3	2.47	-15.1	9.9	23.8	-5.31	18	-0.17	0.94	0.14	1
81	-16.9	-13.8	-12.2	5.08	-8.33	-1.07	8.83	5.84	18	0.31	0.37	0.27	0.47
82	-3.98	-13.4	-14.3	2.33	-0.621	0.416	-2.18	3.09	18	0.08	0.23	0.12	0.03
83	0.246	-13	-12.6	0.417	2.82	0.238	-5.89	1.77	18	0.01	0.18	0.02	0.15
84	0.577	-13.6	-10.2	-0.347	4.79	-0.177	-7.12	0.935	18	0.01	0.17	0.02	0.26
85	-0.129	-14.9	-7.75	-0.515	5.92	-0.445	-7.43	0.387	18	0	0.19	0.02	0.32
86	-0.767	-16.5	-5.43	-0.424	6.52	-0.456	-7.45	-0.0251	18	0.01	0.23	0.02	0.35
87	-0.79	-18.3	-3.23	-0.217	6.59	-0.154	-7.27	-0.527	18	0.01	0.26	0.01	0.35

D-87

✓NRH 4-8-92

JMT 2-11-92 Pg 35

✓NEH
4-8-92

INT
2-11-92
Pg 36

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
88	0.265	-20.9	-1.46	-0.201	5.98	0.342	-6.34	-1.38	18	0.01	0.32	0.01	0.32
89	1.47	-27	-1.6	-2.01	5.26	0.0912	-3.58	-1.98	18	0.03	0.47	0.1	0.28
90	-1.25	-37.2	-2.65	-7.02	16	-1.29	-3.21	0.727	18	0.01	0.68	0.38	0.83
91	7.72	-14.2	-3.75	6.3	-16.3	-0.05	11.8	0.518	18	0.14	0.41	0.34	0.95
92	-23.8	-25.8	-14.2	12.6	-7.6	-2.9	13.1	0.373	18	0.42	0.65	0.66	0.45
93	-3.04	-16.4	-13.2	5.05	-0.185	0.43	-0.18	2.27	18	0.06	0.31	0.26	0.01
94	3.38	-9.73	-11.5	1.79	1.52	0.677	-4.12	1.94	18	0.07	0.13	0.09	0.08
95	4.98	-6.57	-9.82	0.491	2.49	0.48	-5.52	1.22	18	0.1	0.06	0.03	0.13
96	5.04	-5.52	-7.97	-0.0419	3.19	0.301	-5.96	0.555	18	0.1	0.03	0	0.17
97	4.74	-5.7	-6.07	-0.24	3.59	0.261	-5.99	-0.0383	18	0.09	0.03	0.01	0.19
98	4.58	-6.78	-4.43	-0.349	3.67	0.349	-5.7	-0.65	18	0.09	0.06	0.02	0.2
99	4.5	-8.88	-3.68	-0.723	3.58	0.361	-4.84	-1.26	18	0.09	0.11	0.04	0.19
100	3.29	-11.9	-4.89	-1.76	3.87	-0.0196	-3.35	-1.29	18	0.06	0.18	0.1	0.21
101	1.21	-13.9	-6.24	-1.66	9.78	-0.161	-2.72	-0.0746	18	0.02	0.23	0.09	0.52
102	-5.75	-27.7	-8.38	-5.78	0.686	-0.416	-2.32	0.996	18	0.1	0.5	0.31	0.04
103	-21.4	-31.4	-10.7	12.3	13.9	-3.86	-5.79	-3.44	18.1	0.36	0.53	0.64	0.72
104	-2.26	-16.2	-7.91	4.69	2.67	-0.905	-0.788	1.52	18	0.03	0.3	0.25	0.14
105	4.6	-7.72	-8.5	2.28	0.988	0.275	-2.7	1.77	18	0.09	0.11	0.12	0.05
106	7.24	-3.24	-8.36	1.03	1.09	0.602	-3.91	1.26	18.1	0.14	0.01	0.05	0.06
107	8.03	-1.13	-7.45	0.335	1.4	0.648	-4.39	0.625	18	0.16	0	0.02	0.04
108	8.01	-0.475	-6.2	-0.0635	1.62	0.634	-4.45	-0.00011	18	0.16	0	0	0.05
109	7.55	-0.816	-5.1	-0.379	1.72	0.588	-4.2	-0.585	18	0.15	0	0.02	0.05
110	6.48	-1.81	-4.71	-0.783	1.82	0.418	-3.59	-1.01	18	0.13	0	0.04	0.05
111	4.14	-2.69	-5.47	-1.16	2.07	0.1	-2.78	-0.944	18	0.08	0.02	0.06	0.11
112	1.42	-2.75	-5.62	-0.878	5.87	-0.0168	-2.37	-0.27	18	0.03	0.02	0.05	0.31
113	-4.5	-14.9	-6.5	-3.06	1.99	0.0273	-1.86	0.951	18	0.08	0.26	0.16	0.11
114	-9.94	-13.5	-5.7	2.32	5.57	0.663	-2.92	-1.5	18	0.2	0.22	0.12	0.3
115	-1.34	-8.36	-5	3.12	2.14	-0.943	-1.8	-0.0105	18	0.01	0.14	0.17	0.12
116	4.74	-4.33	-6.33	2.07	0.837	0.0149	-1.81	1	18	0.09	0.06	0.11	0.05
117	8.03	-1.35	-6.95	1.14	0.443	0.603	-2.48	0.973	18.1	0.16	0	0.06	0.01
118	9.45	0.471	-6.71	0.489	0.395	0.836	-2.86	0.558	18	0.19	0	0.03	0.01
119	9.68	1.3	-5.98	0.0351	0.44	0.873	-2.93	0.0387	18	0.19	0	0	0.01
120	9.03	1.41	-5.19	-0.334	0.497	0.772	-2.78	-0.442	18	0.18	0	0.02	0.01
121	7.41	1.21	-4.75	-0.661	0.585	0.525	-2.42	-0.739	18	0.15	0	0.03	0.02
122	4.53	1.32	-4.8	-0.844	0.732	0.186	-2.03	-0.67	18	0.09	0	0.04	0.04
123	1.37	1.72	-4.25	-0.844	3.09	0.0136	-1.95	-0.24	18	0.03	0.01	0.04	0.17
124	-2.34	-7.1	-4.39	-1.83	1.28	0.143	-1.31	0.553	18	0.05	0.12	0.09	0.07
125	-5.76	-5.81	-4.56	0.782	2.88	0.711	-1.5	-0.665	18	0.12	0.09	0.04	0.16
126	-1.13	-3.71	-4.49	2.22	1.26	0.0514	-1.3	-0.116	18	0.02	0.05	0.11	0.07
127	4.45	-1.88	-5.61	1.73	0.432	0.187	-1.27	0.479	18	0.09	0.02	0.09	0.02
128	8.13	-0.344	-6.32	1.04	0.0689	0.706	-1.46	0.641	18	0.16	0	0.05	0
129	9.98	0.737	-6.29	0.434	-0.0633	1.03	-1.65	0.418	18	0.2	0	0.02	0
130	10.4	1.31	-5.75	-0.044	-0.0994	1.12	-1.69	0.0451	18	0.21	0	0	0.01
131	9.7	1.5	-5.03	-0.439	-0.0948	0.994	-1.62	-0.306	18	0.19	0.01	0.02	0.01

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
132	7.85	1.57	-4.4	-0.776	-0.0774	0.693	-1.45	-0.495	18	0.16	0.01	0.04	0
133	4.78	1.94	-3.89	-1	-0.0676	0.297	-1.28	-0.428	17.9	0.09	0.02	0.05	0
134	1.36	2.46	-2.95	-1.09	1.34	0.0262	-1.42	-0.19	18	0.03	0.03	0.06	0.07
135	-1.57	-1.68	-2.56	0.00163	1.43	0.386	-0.462	0.164	18	0.03	0.03	0	0.08
136	-4.33	-1.88	-3.33	2.16	1.23	0.595	-0.467	-0.457	18	0.09	0.03	0.11	0.07
137	-1.11	-1.18	-3.86	3.58	0.616	0.416	-0.466	-0.177	18	0.03	0.02	0.19	0.03
138	4.04	-0.572	-4.79	3.88	0.256	0.51	-0.517	0.167	18	0.08	0	0.2	0.01
139	7.95	-0.108	-5.28	3.56	-0.0343	0.96	-0.549	0.309	18	0.16	0	0.19	0
140	10.1	0.245	-5.21	2.96	-0.217	1.4	-0.574	0.241	18	0.21	0	0.16	0.01
141	10.7	0.46	-4.74	2.27	-0.308	1.56	-0.58	0.0708	18	0.22	0	0.12	0.02
142	0.401	0.369	0.501	-0.347	-0.386	41.9	-9.09	-10.8	12	-0.46	0	0.07	0.02
143	-0.00877	-0.0168	0.584	-0.504	0.249	34	3.89	-7.63	12	-0.35	-0.04	0.08	0.02
144	-0.25	-0.342	0.401	-0.213	0.32	27.1	1.13	-5.28	12	-0.29	0.03	0.03	0.03
145	-0.257	-0.344	0.151	-0.0732	0.224	21.7	0.147	-3.5	12	-0.24	0.01	0.01	0.02
146	-0.187	-0.264	-0.0382	-0.0316	0.155	18	-0.0643	-2.47	12	-0.2	0.01	0	0.01
147	-0.136	-0.207	-0.167	-0.018	0.129	15.3	-0.168	-1.82	12	-0.17	0	0	0.01
148	-0.106	-0.176	-0.255	-0.0117	0.117	13.3	-0.234	-1.42	12	-0.14	0	0	0.01
149	-0.0872	-0.158	-0.318	-0.0079	0.109	11.7	-0.279	-1.18	12	-0.13	0	0	0.01
150	-0.0745	-0.146	-0.365	-0.00533	0.103	10.3	-0.31	-1.08	12	-0.11	0	0	0.01
151	-0.0645	-0.137	-0.4	-0.00355	0.0975	8.91	-0.332	-1.09	12	-0.1	0	0	0.01
152	-0.0551	-0.129	-0.426	-0.00244	0.0923	7.49	-0.347	-1.2	12	-0.08	0	0	0
153	-0.045	-0.12	-0.441	-0.00222	0.0864	5.87	-0.356	-1.41	12	-0.06	0	0	0
154	-0.0333	-0.109	-0.445	-0.00348	0.0794	3.92	-0.359	-1.72	12	-0.04	0	0	0
155	-0.019	-0.0965	-0.434	-0.00717	0.0707	1.53	-0.358	-2.13	12	-0.02	0	0	0
156	-0.00149	-0.0804	-0.406	-0.0147	0.0599	-1.45	-0.351	-2.64	12	0	0	0	0
157	0.0193	-0.0608	-0.354	-0.0278	0.0471	-5.14	-0.337	-3.24	12	0	0	0	0
158	0.0427	-0.0379	-0.278	-0.0486	0.0324	-9.65	-0.317	-3.9	12	0	0	0	0
159	0.0664	-0.0131	-0.173	-0.0799	0.017	-15.1	-0.287	-4.57	12	0	0	0	0
160	0.0842	0.00986	-0.0434	-0.126	0.00366	-21.4	-0.246	-5.16	12	0	0	0.01	0
161	0.0774	0.0162	0.094	-0.193	0.00343	-28.6	-0.194	-5.47	12	0	0	0.01	0
162	-0.00258	-0.0529	0.189	-0.291	0.0615	-36.3	-0.132	-5.17	12	0	0	0.01	0
163	-0.22	-0.374	0.148	-0.36	0.319	-43.7	-0.21	-3.55	12	0	0.01	0.01	0.03
164	-0.315	-1.2	0.0191	0.0678	0.871	-50.5	-2.63	0.259	12	0	0	0	0.08
165	4.02	1.21	2.29	4.58	2.82	-58.6	-10.3	4.05	12	0	0	0.17	0.13
166	-8.78	4.01	6.13	8.04	5.97	0.0561	0.488	-0.126	24	0.12	0.06	0.3	0.22
167	-7.2	4.51	3.61	2.69	0.856	-0.142	0.149	0.0193	24	0.09	0.06	0.1	0.03
168	-5.72	1.51	2.46	2.74	0.512	-0.0653	-0.065	0.046	24	0.08	0.02	0.11	0.02
169	-4.84	0.164	2.16	3.01	1.19	0.0118	-0.0478	0.0206	24	0.06	0	0.11	0.05
170	-4.28	0.128	2.14	2.88	1.35	0.018	-0.0194	0.00878	24	0.06	0	0.11	0.05
171	-3.94	0.293	2.17	2.8	1.31	0.0128	-0.00738	0.0056	24	0.05	0	0.1	0.05
172	-3.79	0.349	2.25	2.81	1.25	0.0101	-0.0044	0.00502	24	0.05	0	0.1	0.05
173	-3.75	0.291	2.37	2.86	1.24	0.0103	-0.00427	0.00484	24	0.05	0	0.11	0.05
174	-3.75	0.169	2.52	2.91	1.27	0.0118	-0.00466	0.00466	24	0.05	0	0.11	0.05

✓ NRH 4-8-92

DMT 2-11-92 p. 37

175	-3.74	0.0208	2.68	2.96	1.33	0.0135	-0.00475	0.00452	24	0.05	0	0.11	0.05

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
176	-3.68	-0.134	2.86	2.99	1.4	0.0147	-0.00421	0.00453	24	0.05	0	0.11	0.05
177	-3.53	-0.285	3.04	3.01	1.47	0.0146	-0.0028	0.00482	24	0.05	0	0.11	0.06
178	-3.28	-0.423	3.22	3.01	1.54	0.0125	-0.00020	0.00557	24	0.04	0.01	0.11	0.06
179	-2.89	-0.539	3.4	2.98	1.61	0.00698	0.00402	0.00701	24	0.04	0.01	0.11	0.06
180	-2.3	-0.623	3.56	2.92	1.66	-0.00364	0.0105	0.00948	24	0.03	0.01	0.11	0.06
181	-1.45	-0.657	3.71	2.8	1.7	-0.0221	0.0197	0.0135	24	0.02	0.01	0.11	0.06
182	-0.256	-0.621	3.84	2.59	1.7	-0.052	0.0322	0.0197	24	0	0.01	0.1	0.06
183	1.4	-0.498	3.93	2.24	1.65	-0.097	0.0471	0.0286	24	0.02	0.01	0.09	0.06
184	3.59	-0.285	3.99	1.68	1.5	-0.158	0.0599	0.0404	24	0.05	0	0.07	0.06
185	6.3	-0.0383	3.99	0.796	1.17	-0.222	0.0576	0.0533	24	0.08	0	0.03	0.04
186	9.24	0.0993	3.9	-0.53	0.518	-0.241	0.0104	0.0621	24	0.12	0	0.02	0.02
187	11.4	-0.103	3.49	-2.36	-0.543	-0.125	-0.112	0.0572	24	0.15	0	0.09	0.02
188	10.2	-1.24	2.03	-4.33	-1.99	-0.0304	-0.0847	0.0238	24	0.14	0.02	0.17	0.08
189	4.84	-3.81	-1.73	-2.52	-2.4	-0.302	0.325	-0.0064	24	0.06	0.05	0.1	0.09
190	3.41	1.4	5.93	5.67	0.8	-0.0758	0.0802	-0.129	24	0.04	0.02	0.22	0.03
191	3.19	3.61	5.45	2.11	-0.0915	0.0367	0.0827	-0.00796	24	0.04	0.05	0.08	0
192	2.96	2.86	3.82	1.88	-0.228	-0.0371	-0.00548	0.0432	24	0.04	0.04	0.07	0.01
193	3	2.24	3.07	2	-0.038	-0.0288	-0.0379	0.0289	24	0.04	0.03	0.08	0
194	3.1	2.28	2.89	1.97	0.0261	-0.00379	-0.0275	0.0169	24	0.04	0.03	0.08	0
195	3.18	2.46	2.86	1.94	0.0126	0.00595	-0.0148	0.00998	24	0.04	0.03	0.07	0
196	3.25	2.58	2.92	1.93	-0.0179	0.00817	-0.00807	0.00683	24	0.04	0.03	0.07	0
197	3.31	2.59	3.05	1.95	-0.0407	0.00871	-0.0053	0.00567	24	0.04	0.03	0.07	0
198	3.39	2.54	3.23	1.98	-0.0519	0.00928	-0.00419	0.00547	24	0.05	0.03	0.07	0
199	3.48	2.44	3.45	2	-0.0543	0.00989	-0.0034	0.00575	24	0.05	0.03	0.07	0
200	3.61	2.32	3.69	2.02	-0.051	0.0101	-0.00225	0.00634	24	0.05	0.03	0.07	0
201	3.77	2.19	3.95	2.02	-0.0437	0.00919	-0.00025	0.00721	24	0.05	0.03	0.07	0
202	3.99	2.04	4.22	2	-0.033	0.00654	0.00301	0.00837	24	0.05	0.03	0.07	0
203	4.27	1.9	4.49	1.95	-0.0185	0.00129	0.00807	0.00981	24	0.06	0.03	0.07	0
204	4.62	1.75	4.76	1.86	0.000239	-0.00755	0.0155	0.0114	23.9	0.06	0.02	0.07	0
205	5.07	1.6	5.03	1.72	0.0226	-0.0211	0.0257	0.013	24	0.07	0.02	0.07	0
206	5.6	1.42	5.27	1.48	0.0444	-0.0402	0.0383	0.0139	24	0.07	0.02	0.06	0
207	6.22	1.21	5.47	1.12	0.0529	-0.0647	0.0512	0.0136	24	0.08	0.02	0.04	0
208	6.84	0.871	5.56	0.574	0.017	-0.0921	0.058	0.0124	24	0.09	0.01	0.02	0
209	7.29	0.241	5.4	-0.208	-0.128	-0.115	0.0445	0.0139	24	0.1	0	0.01	0
210	7.23	-1.03	4.76	-1.27	-0.5	-0.126	-0.0104	0.0286	24	0.1	0.01	0.05	0.02
211	6.03	-3.62	3.16	-2.56	-1.28	-0.133	-0.106	0.0669	24	0.08	0.05	0.1	0.05
212	2.97	-8.59	-0.304	-4.05	-2.64	-0.161	-0.119	0.0828	24	0.04	0.11	0.16	0.1
213	-1.82	-16.8	-5.26	-1.77	-4.13	-0.204	0.0433	0.0504	24.1	0.02	0.23	0.07	0.15
214	10.3	0.9	4.21	3.78	0.413	-0.0742	0.00534	-0.0606	24	0.14	0.01	0.15	0.02
215	9.67	2.65	4.49	1.28	0.122	0.0068	-0.00226	-0.0295	24	0.13	0.04	0.05	0
216	8.88	3.24	3.52	1.1	-0.0702	-0.0073	-0.00317	0.016	24	0.12	0.04	0.04	0
217	8.28	3.42	2.93	1.2	-0.0209	-0.0211	-0.018	0.0196	24.1	0.11	0.05	0.05	0

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4-8-92

DMT
2-11-92
F.22

218	7.98	3.66	2.77	1.19	0.0292	-0.0135	-0.0226	0.0134	23.9	0.11	0.05	0.05	0
219	7.84	3.92	2.79	1.18	0.0436	-0.00265	-0.0172	0.00889	24	0.1	0.05	0.05	0

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
220	7.8	4.1	2.9	1.17	0.0384	0.00314	-0.0107	0.00647	24	0.1	0.05	0.04	0
221	7.84	4.18	3.07	1.18	0.0281	0.0054	-0.00616	0.00545	24.1	0.1	0.06	0.04	0
222	7.91	4.18	3.29	1.18	0.0192	0.00626	-0.00331	0.00529	23.9	0.11	0.06	0.04	0
223	8.02	4.12	3.53	1.19	0.0127	0.0066	-0.00122	0.0056	24	0.11	0.06	0.04	0
224	8.15	4.02	3.8	1.19	0.0074	0.00646	0.000927	0.00615	24	0.11	0.05	0.04	0
225	8.28	3.9	4.08	1.18	0.00129	0.0055	0.00372	0.00678	24	0.11	0.05	0.04	0
226	8.41	3.74	4.37	1.15	-0.00775	0.00328	0.00766	0.00734	24	0.11	0.05	0.04	0
227	8.53	3.55	4.66	1.09	-0.0224	-0.00062	0.0132	0.00762	23.9	0.11	0.05	0.04	0
228	8.61	3.32	4.95	0.998	-0.0467	-0.00649	0.0206	0.00729	24	0.12	0.04	0.04	0
229	8.61	3.01	5.23	0.85	-0.0877	-0.0143	0.0298	0.00589	24	0.12	0.04	0.03	0
230	8.5	2.59	5.47	0.626	-0.158	-0.0233	0.0396	0.00293	24	0.11	0.04	0.02	0.01
231	8.19	1.98	5.62	0.302	-0.28	-0.0325	0.0466	-0.00157	24	0.11	0.03	0.01	0.01
232	7.55	0.998	5.6	-0.154	-0.495	-0.0403	0.0447	-0.006	23.9	0.1	0.01	0.01	0.02
233	6.39	-0.642	5.23	-0.768	-0.865	-0.0464	0.0256	-0.00546	24	0.08	0.01	0.03	0.03
234	4.46	-3.47	4.22	-1.54	-1.49	-0.0542	-0.0168	0.00749	24	0.06	0.05	0.06	0.06
235	1.51	-8.35	2.13	-2.43	-2.46	-0.0691	-0.0756	0.0321	24	0.02	0.11	0.09	0.1
236	-2.58	-16.6	-1.74	-3.47	-3.85	-0.0711	-0.128	0.0425	24	0.03	0.22	0.13	0.15
237	-7.64	-29.6	-6.32	-0.699	-5.67	-0.0413	-0.206	0.0658	24	0.1	0.4	0.03	0.22
238	13.9	0.781	2.62	2.14	0.329	-0.0581	-0.00157	-0.0186	24	0.19	0.01	0.08	0.01
239	13.1	2.39	3.07	0.563	0.085	-0.0153	-0.00937	-0.0192	24	0.18	0.03	0.02	0
240	12.1	3.4	2.64	0.496	-0.0525	-0.00897	-0.00876	0.00123	24	0.16	0.05	0.02	0
241	11.1	4.05	2.42	0.552	-0.0248	-0.0118	-0.00927	0.009	24	0.15	0.05	0.02	0
242	10.6	4.5	2.46	0.554	0.0119	-0.0125	-0.0124	0.00762	24	0.14	0.06	0.02	0
243	10.3	4.84	2.63	0.548	0.0305	-0.00757	-0.0122	0.00524	24	0.14	0.06	0.02	0
244	10.2	5.06	2.85	0.541	0.0334	-0.00233	-0.00896	0.00403	24	0.14	0.07	0.02	0
245	10.2	5.18	3.1	0.537	0.0286	0.000971	-0.00509	0.0037	24	0.14	0.07	0.02	0
246	10.2	5.2	3.36	0.534	0.0207	0.00268	-0.00169	0.0038	24	0.14	0.07	0.02	0
247	10.3	5.16	3.64	0.529	0.0105	0.00349	0.00127	0.00407	24	0.14	0.07	0.02	0
248	10.4	5.07	3.91	0.519	-0.00317	0.00373	0.00421	0.0043	24	0.14	0.07	0.02	0
249	10.5	4.93	4.19	0.498	-0.0227	0.00339	0.00757	0.00434	24	0.14	0.07	0.02	0
250	10.5	4.74	4.46	0.462	-0.0514	0.00232	0.0117	0.00396	24	0.14	0.06	0.02	0
251	10.5	4.49	4.72	0.404	-0.094	0.000416	0.0169	0.00289	24	0.14	0.06	0.01	0
252	10.3	4.15	4.94	0.315	-0.157	-0.00217	0.0232	0.000793	24	0.14	0.06	0.01	0.01
253	9.94	3.69	5.13	0.184	-0.253	-0.00483	0.0303	-0.00263	24	0.13	0.05	0.01	0.01
254	9.31	3.01	5.23	-0.00173	-0.396	-0.00634	0.0365	-0.00744	24.1	0.12	0.04	0	0.01
255	8.29	1.99	5.19	-0.258	-0.615	-0.00527	0.0389	-0.0131	24	0.11	0.03	0.01	0.02
256	6.76	0.388	4.92	-0.597	-0.949	-0.00134	0.0323	-0.0178	24	0.09	0.01	0.02	0.04
257	4.57	-2.18	4.26	-1.02	-1.45	0.00261	0.0115	-0.0183	23.9	0.06	0.03	0.04	0.05
258	1.6	-6.36	3	-1.53	-2.2	0.00125	-0.0248	-0.011	24	0.02	0.08	0.06	0.08
259	-2.23	-13.1	0.819	-2.08	-3.24	-0.00452	-0.0735	0.00416	24	0.03	0.17	0.08	0.12
260	-6.75	-23.8	-2.66	-2.69	-4.64	0.00509	-0.139	0.0224	24	0.09	0.32	0.1	0.18

✓ NRH 4-8-90

JMT 2-11-9? pg 30

✓ N.R.+
4-8-92

DMT
2-11-92
P. 40

261	-11.9	-39.8	-6.14	0.107	-6.41	0.0288	-0.248	0.0677	23.9	0.16	0.54	0	0.25
262	15.1	0.762	1.04	0.707	0.315	-0.0482	-0.00328	0.00394	24	0.2	0.01	0.03	0.01
263	14.2	2.37	1.45	0.00204	0.0762	-0.0216	-0.00615	-0.006	24	0.19	0.03	0	0

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
264	13	3.56	1.48	0.0276	-0.0419	-0.0136	-0.00658	-0.00050	24	0.17	0.05	0	0
265	12	4.45	1.69	0.0584	-0.0148	-0.00929	-0.00463	0.0021	24	0.16	0.06	0	0
266	11.3	5.03	2.02	0.0607	0.00771	-0.0102	-0.00439	0.00216	24	0.15	0.07	0	0
267	11	5.4	2.39	0.0565	0.0202	-0.0092	-0.0048	0.00135	24	0.15	0.07	0	0
268	10.8	5.63	2.76	0.0464	0.0236	-0.0063	-0.00398	0.00102	24	0.14	0.08	0	0
269	10.7	5.73	3.1	0.0345	0.0207	-0.00328	-0.00188	0.00117	24	0.14	0.08	0	0
270	10.8	5.74	3.42	0.0223	0.0131	-0.00098	0.000844	0.00144	24	0.14	0.08	0	0
271	10.9	5.69	3.72	0.00859	0.000245	0.000597	0.00383	0.00157	24	0.15	0.08	0	0
272	10.9	5.57	4	-0.00916	-0.0197	0.00169	0.00704	0.0014	24	0.15	0.07	0	0
273	10.9	5.4	4.25	-0.0342	-0.0497	0.00245	0.0106	0.00078	24	0.15	0.07	0	0
274	10.9	5.15	4.47	-0.0706	-0.0938	0.00297	0.0144	-0.00046	24	0.15	0.07	0	0
275	10.7	4.82	4.65	-0.123	-0.158	0.00335	0.0187	-0.00257	24	0.14	0.06	0	0.01
276	10.3	4.35	4.76	-0.197	-0.251	0.00386	0.0232	-0.00575	24	0.14	0.06	0.01	0.01
277	9.72	3.7	4.79	-0.298	-0.385	0.00512	0.0274	-0.0101	24	0.13	0.05	0.01	0.01
278	8.74	2.75	4.68	-0.432	-0.578	0.00827	0.0305	-0.0154	24	0.12	0.04	0.02	0.02
279	7.29	1.34	4.39	-0.605	-0.857	0.0149	0.0303	-0.0207	24	0.1	0.02	0.02	0.03
280	5.27	-0.801	3.83	-0.817	-1.26	0.026	0.0231	-0.0247	24	0.07	0.01	0.03	0.05
281	2.55	-4.12	2.92	-1.06	-1.83	0.0387	0.00315	-0.0256	24	0.03	0.06	0.04	0.07
282	-0.914	-9.27	1.54	-1.32	-2.61	0.0447	-0.0328	-0.022	23.9	0.01	0.12	0.05	0.1
283	-5.07	-17.2	-0.433	-1.58	-3.67	0.0394	-0.0808	-0.00995	24	0.07	0.23	0.06	0.14
284	-9.68	-29.4	-3.12	-1.86	-5.03	0.0359	-0.138	0.0174	24	0.13	0.4	0.07	0.19
285	-14.7	-47	-5.33	0.587	-6.67	0.042	-0.215	0.0658	24	0.2	0.64	0.02	0.26
286	14.4	0.815	-0.56	-0.553	0.332	-0.043	-0.00506	0.019	24	0.19	0.01	0.02	0.01
287	13.5	2.52	-0.265	-0.399	0.0967	-0.0205	-0.00366	0.0032	24	0.18	0.03	0.02	0
288	12.3	3.85	0.187	-0.298	-0.0224	-0.0156	-0.00241	0.00197	24	0.16	0.05	0.01	0
289	11.2	4.84	0.86	-0.282	-0.00375	-0.00959	0.000787	-0.00129	24	0.15	0.06	0.01	0
290	10.5	5.44	1.53	-0.281	0.0022	-0.0097	0.00241	-0.00202	24	0.14	0.07	0.01	0
291	10.1	5.77	2.14	-0.292	0.00475	-0.0101	0.00224	-0.00198	24	0.14	0.08	0.01	0
292	9.97	5.93	2.66	-0.31	0.00555	-0.00884	0.00179	-0.00168	24	0.13	0.08	0.01	0
293	9.93	5.97	3.1	-0.331	0.00343	-0.00652	0.00222	-0.00134	24	0.13	0.08	0.01	0
294	9.96	5.92	3.48	-0.352	-0.00354	-0.00405	0.00376	-0.00117	24	0.13	0.08	0.01	0
295	10	5.82	3.8	-0.373	-0.0176	-0.00183	0.00616	-0.00134	24	0.13	0.08	0.01	0
296	10.1	5.65	4.07	-0.396	-0.0414	0.000185	0.00912	-0.00197	24	0.14	0.08	0.01	0
297	10	5.41	4.29	-0.423	-0.0783	0.0022	0.0124	-0.00315	24	0.13	0.07	0.02	0
298	9.95	5.08	4.45	-0.456	-0.133	0.00444	0.0158	-0.00501	24	0.13	0.07	0.02	0
299	9.7	4.63	4.52	-0.499	-0.211	0.00713	0.0189	-0.00767	24	0.13	0.06	0.02	0.01
300	9.24	4.01	4.5	-0.552	-0.322	0.0105	0.0213	-0.0112	24	0.12	0.05	0.02	0.01
301	8.5	3.16	4.34	-0.618	-0.478	0.0147	0.0226	-0.0156	24	0.11	0.04	0.02	0.02
302	7.39	1.94	4	-0.696	-0.695	0.0203	0.0224	-0.0206	24	0.1	0.03	0.03	0.03
303	5.8	0.184	3.44	-0.783	-0.999	0.0285	0.0204	-0.0252	24	0.08	0	0.03	0.04

DMT
2-11-92
Pg 41

✓NRH
4-8-92

304	3.62	-2.39	2.62	-0.87	-1.42	0.0414	0.0154	-0.0282	24	0.05	0.03	0.03	0.05
305	0.787	-6.2	1.5	-0.944	-2	0.0606	0.00271	-0.0285	24	0.01	0.08	0.03	0.07
306	-2.74	-11.9	0.0902	-0.986	-2.77	0.0784	-0.0284	-0.0264	24	0.04	0.16	0.04	0.11
307	-6.9	-20.4	-1.54	-0.99	-3.8	0.073	-0.0819	-0.0189	24	0.09	0.27	0.04	0.15

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
308	-11.4	-33	-3.27	-0.986	-5.12	0.0411	-0.135	0.0121	24	0.15	0.44	0.04	0.2
309	-16.3	-51.3	-4.17	0.909	-6.83	0.0275	-0.176	0.0696	24	0.22	0.7	0.03	0.26
310	12.4	1	-2.26	-1.69	0.391	-0.0385	-0.00732	0.0329	24	0.17	0.01	0.07	0.02
311	11.5	2.95	-2.08	-0.658	0.15	-0.0154	-0.00114	0.00833	24	0.15	0.04	0.03	0.01
312	10.2	4.43	-1.14	-0.48	0.0165	-0.0164	0.00315	0.00446	24	0.14	0.06	0.02	0
313	9.17	5.41	0.0537	-0.475	0.00222	-0.0112	0.00804	-0.00317	24	0.12	0.07	0.02	0
314	8.58	5.89	1.09	-0.484	-0.0173	-0.0112	0.00956	-0.00475	24	0.11	0.08	0.02	0
315	8.28	6.06	1.93	-0.512	-0.0245	-0.0115	0.00852	-0.00428	24	0.11	0.08	0.02	0
316	8.15	6.07	2.59	-0.546	-0.0239	-0.0106	0.0068	-0.00367	24	0.11	0.08	0.02	0
317	8.12	5.99	3.12	-0.579	-0.0234	-0.00855	0.00584	-0.00341	24	0.11	0.08	0.02	0
318	8.16	5.85	3.54	-0.608	-0.0281	-0.00609	0.00618	-0.00357	24	0.11	0.08	0.02	0
319	8.2	5.66	3.88	-0.635	-0.0415	-0.00352	0.00775	-0.00418	24	0.11	0.08	0.02	0
320	8.24	5.41	4.14	-0.662	-0.0666	-0.00081	0.0102	-0.00529	24	0.11	0.07	0.03	0
321	8.22	5.07	4.32	-0.69	-0.107	0.00225	0.0131	-0.00695	24	0.11	0.07	0.03	0
322	8.11	4.63	4.42	-0.719	-0.166	0.00601	0.0159	-0.00919	24	0.11	0.06	0.03	0.01
323	7.86	4.05	4.4	-0.751	-0.25	0.0107	0.0181	-0.012	24	0.11	0.05	0.03	0.01
324	7.42	3.26	4.24	-0.783	-0.368	0.0166	0.0189	-0.0154	24	0.1	0.04	0.03	0.01
325	6.72	2.18	3.91	-0.815	-0.529	0.0235	0.0178	-0.0192	24	0.09	0.03	0.03	0.02
326	5.67	0.704	3.37	-0.84	-0.748	0.031	0.0142	-0.0231	24	0.08	0.01	0.03	0.03
327	4.2	-1.34	2.57	-0.847	-1.04	0.0386	0.00887	-0.0267	24	0.06	0.02	0.03	0.04
328	2.2	-4.22	1.52	-0.822	-1.44	0.0473	0.00433	-0.0294	24	0.03	0.06	0.03	0.05
329	-0.391	-8.29	0.229	-0.742	-1.98	0.0631	0.00317	-0.0303	24	0.01	0.11	0.03	0.07
330	-3.63	-14.1	-1.19	-0.579	-2.69	0.0941	-0.00271	-0.0289	24	0.05	0.19	0.02	0.1
331	-7.48	-22.4	-2.51	-0.327	-3.64	0.114	-0.0479	-0.0276	24	0.1	0.3	0.01	0.14
332	-11.7	-34.5	-3.32	0.0588	-4.92	0.0516	-0.138	-0.00428	24	0.16	0.46	0	0.19
333	-16.6	-52.5	-2.83	1.38	-7.03	-0.0192	-0.176	0.0971	24	0.22	0.71	0.05	0.27
334	9.55	1.54	-4.25	-2.77	0.537	-0.03	-0.0128	0.0492	24	0.13	0.02	0.11	0.02
335	8.44	3.97	-4.04	-0.753	0.259	-0.00701	0.00279	0.00856	24	0.11	0.05	0.03	0.01
336	7.26	5.6	-2.42	-0.466	0.0713	-0.0187	0.0115	0.00595	24	0.1	0.07	0.02	0
337	6.38	6.36	-0.599	-0.483	-0.0259	-0.015	0.0183	-0.00455	24	0.09	0.09	0.02	0
338	5.97	6.5	0.793	-0.533	-0.0699	-0.0147	0.0176	-0.006	24	0.08	0.09	0.02	0
339	5.78	6.37	1.82	-0.597	-0.0732	-0.0135	0.0139	-0.00533	24	0.08	0.09	0.02	0
340	5.71	6.16	2.59	-0.652	-0.0637	-0.0115	0.0103	-0.0049	24	0.08	0.08	0.03	0
341	5.71	5.91	3.18	-0.696	-0.0558	-0.00923	0.00812	-0.00503	24	0.08	0.08	0.03	0
342	5.75	5.64	3.63	-0.734	-0.0557	-0.00684	0.00748	-0.00565	24	0.08	0.08	0.03	0
343	5.8	5.33	3.98	-0.767	-0.0664	-0.00428	0.00823	-0.0067	24	0.08	0.07	0.03	0
344	5.84	4.97	4.23	-0.797	-0.0904	-0.00133	0.01	-0.00822	24	0.08	0.07	0.03	0
345	5.83	4.52	4.39	-0.825	-0.13	0.00234	0.0124	-0.0102	24	0.08	0.06	0.03	0
346	5.76	3.95	4.44	-0.851	-0.19	0.00714	0.0147	-0.0128	24	0.08	0.05	0.03	0.01

D-93

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
347	5.57	3.2	4.35	-0.874	-0.273	0.0134	0.0165	-0.0157	24	0.07	0.04	0.03	0.01
348	5.24	2.22	4.1	-0.89	-0.387	0.0214	0.0167	-0.0187	24	0.07	0.03	0.03	0.01
349	4.69	0.917	3.64	-0.893	-0.54	0.0308	0.0145	-0.0216	24	0.06	0.01	0.03	0.02
350	3.89	-0.806	2.94	-0.875	-0.743	0.0409	0.00882	-0.0239	24	0.05	0.01	0.03	0.03
351	2.75	-3.1	1.98	-0.819	-1.01	0.0494	-0.00062	-0.0253	24	0.04	0.04	0.03	0.04

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
352	1.21	-6.16	0.749	-0.704	-1.36	0.0534	-0.0113	-0.0267	24	0.02	0.08	0.03	0.05
353	-0.797	-10.3	-0.673	-0.495	-1.81	0.0529	-0.0134	-0.0303	24	0.01	0.14	0.02	0.07
354	-3.34	-15.8	-2.13	-0.149	-2.39	0.0664	0.0113	-0.0384	24	0.05	0.21	0.01	0.09
355	-6.46	-23.4	-3.28	0.384	-3.15	0.136	0.0544	-0.0483	24	0.09	0.32	0.01	0.12
356	-10.1	-33.9	-3.41	1.39	-4.21	0.144	-0.0389	-0.0507	24	0.14	0.46	0.05	0.16
357	-14.3	-49.3	-1.33	2.58	-6.51	-0.0371	-0.343	0.165	24	0.19	0.67	0.1	0.25
358	6.06	2.84	-6.83	-3.94	1.21	-0.00746	-0.0292	0.0792	24	0.08	0.04	0.15	0.05
359	4.81	6.43	-6.07	-0.548	0.615	0.000048	-0.014	-0.00648	24	0.06	0.09	0.02	0.02
360	3.92	7.81	-3.36	-0.116	0.219	-0.0281	0.0308	0.0059	24	0.05	0.1	0	0.01
361	3.4	7.79	-0.883	-0.28	-0.0549	-0.0238	0.033	-0.00458	24	0.05	0.1	0.01	0
362	3.19	7.29	0.74	-0.441	-0.125	-0.0196	0.0251	-0.00545	24	0.04	0.1	0.02	0
363	3.12	6.74	1.85	-0.55	-0.137	-0.0145	0.0176	-0.00569	24	0.04	0.09	0.02	0.01
364	3.1	6.25	2.66	-0.62	-0.138	-0.0107	0.0123	-0.00612	24	0.04	0.08	0.02	0.01
365	3.13	5.8	3.26	-0.672	-0.142	-0.00821	0.00916	-0.00673	24	0.04	0.08	0.03	0.01
366	3.17	5.38	3.72	-0.715	-0.153	-0.0062	0.0077	-0.00756	24	0.04	0.07	0.03	0.01
367	3.22	4.94	4.07	-0.753	-0.172	-0.00408	0.00758	-0.00876	24	0.04	0.07	0.03	0.01
368	3.26	4.46	4.32	-0.787	-0.203	-0.00136	0.00849	-0.0104	24	0.04	0.06	0.03	0.01
369	3.28	3.88	4.47	-0.817	-0.247	0.00238	0.0101	-0.0127	24	0.04	0.05	0.03	0.01
370	3.26	3.16	4.5	-0.842	-0.307	0.00762	0.0119	-0.0155	24	0.04	0.04	0.03	0.01
371	3.18	2.24	4.38	-0.859	-0.385	0.0148	0.0135	-0.0186	24	0.04	0.03	0.03	0.01
372	3.01	1.06	4.09	-0.864	-0.485	0.0241	0.0141	-0.0218	24	0.04	0.01	0.03	0.02
373	2.72	-0.46	3.58	-0.848	-0.612	0.0356	0.0128	-0.0245	24	0.04	0.01	0.03	0.02
374	2.28	-2.41	2.81	-0.8	-0.768	0.0485	0.00831	-0.0256	24	0.03	0.03	0.03	0.03
375	1.64	-4.91	1.78	-0.702	-0.959	0.061	-0.00115	-0.0241	24	0.02	0.07	0.03	0.04
376	0.757	-8.08	0.49	-0.528	-1.19	0.0681	-0.0176	-0.0194	24	0.01	0.11	0.02	0.05
377	-0.414	-12.1	-0.965	-0.244	-1.45	0.0596	-0.0395	-0.015	24.1	0.01	0.16	0.01	0.06
378	-1.91	-17.1	-2.39	0.202	-1.76	0.025	-0.0452	-0.0288	24	0.03	0.23	0.01	0.07
379	-3.71	-23.6	-3.43	0.919	-2.15	0.0154	0.0441	-0.105	24	0.05	0.32	0.03	0.08
380	-5.7	-31.6	-3.24	2.57	-2.64	0.3	0.291	-0.254	24	0.08	0.43	0.1	0.1
381	-7.59	-39.9	0.0637	4.99	-3.24	0.755	-0.677	0.0193	24	0.11	0.53	0.19	0.13
382	1.63	5.54	-7.59	-5.99	7.77	0.105	0.0528	-0.0012	24	0.02	0.07	0.22	0.29
383	2.1	10	-5.78	0.783	4.33	0.0329	0.00888	-0.0102	24	0.03	0.13	0.03	0.16
384	1.47	9.95	-2.54	0.417	1.81	-0.046	0.0432	0.0219	24	0.02	0.13	0.02	0.07
385	1.14	8.77	-0.366	-0.269	0.419	-0.0415	0.0204	0.0079	24	0.01	0.12	0.01	0.02
386	1.05	7.72	0.834	-0.489	-0.389	-0.0246	0.013	0.00294	24	0.01	0.1	0.02	0.01
387	1.02	6.88	1.64	-0.584	-0.937	-0.0144	0.0083	0.000159	24	0.01	0.09	0.02	0.03
388	1.03	6.2	2.22	-0.645	-1.33	-0.00955	0.00533	-0.00145	24	0.01	0.08	0.03	0.05
389	1.04	5.62	2.67	-0.696	-1.61	-0.00728	0.00355	-0.00253	24	0.01	0.08	0.03	0.06

D-94

✓NRH 4-8-92

DMT 2-11-92 Pg 42

390	1.07	5.09	3.02	-0.741	-1.83	-0.00591	0.00266	-0.00345	24	0.01	0.07	0.03	0.07
391	1.09	4.57	3.29	-0.782	-2	-0.00447	0.00247	-0.00448	24	0.01	0.06	0.03	0.07
392	1.11	4	3.5	-0.82	-2.13	-0.00233	0.00289	-0.00582	24	0.01	0.05	0.03	0.08
393	1.12	3.33	3.64	-0.853	-2.21	0.00102	0.00385	-0.00766	24	0.01	0.04	0.03	0.08
394	1.13	2.51	3.69	-0.879	-2.24	0.00609	0.00524	-0.0101	24	0.02	0.03	0.03	0.08
395	1.11	1.48	3.64	-0.896	-2.21	0.0134	0.00693	-0.0132	24	0.01	0.02	0.03	0.08

ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
396	1.07	0.165	3.46	-0.897	-2.11	0.0232	0.0087	-0.0168	24	0.01	0	0.03	0.08
397	0.994	-1.5	3.11	-0.876	-1.92	0.0359	0.0102	-0.0207	24	0.01	0.02	0.03	0.07
398	0.87	-3.59	2.57	-0.821	-1.65	0.051	0.0109	-0.0242	24	0.01	0.05	0.03	0.06
399	0.685	-6.21	1.81	-0.719	-1.3	0.0678	0.00933	-0.026	24	0.01	0.08	0.03	0.05
400	0.428	-9.43	0.81	-0.553	-0.904	0.0838	0.00217	-0.023	24	0.01	0.13	0.02	0.03
401	0.102	-13.3	-0.39	-0.295	-0.589	0.0897	-0.0195	-0.00613	24	0	0.18	0.01	0.02
402	-0.243	-18.1	-1.71	0.109	-0.622	0.046	-0.068	0.0448	24	0	0.24	0	0.02
403	-0.542	-23.9	-3.02	0.734	-1.62	-0.174	-0.105	0.142	24	0.01	0.32	0.03	0.06
404	-1.04	-30.7	-3.95	1.83	-4.23	-0.675	0.256	0.0967	24.1	0.01	0.42	0.07	0.16
405	-1.28	-30.1	-2.11	4.44	-3.37	0.471	0.0347	0.0566	24	0.02	0.41	0.16	0.12
681	-8.93	-5.25	-8.23	7.06	2.51	366	41.9	36.3	36	-3.9	-0.49	-0.24	0.07
682	-4.88	-6.55	-5.15	2.86	0.661	129	-15.6	6.27	36.1	-1.39	0	0.17	0.01
683	-2.68	-5.22	-5.73	1.33	0.979	73.3	-21.1	-4.86	35.9	-0.79	0	0.05	0.01
684	-2.06	-4.04	-6.42	0.95	0.973	42	-14.3	-6.95	36	-0.46	0	0.03	0.01
685	-1.84	-3.38	-7.1	0.91	0.892	28.8	-7.82	-6.33	36	-0.32	0	0.02	0.01
686	-1.69	-3.04	-7.69	0.902	0.848	23	-4.94	-6	36	-0.26	0	0.02	0.01
687	-1.6	-2.91	-8.21	0.902	0.842	19.6	-4.02	-5.97	36	-0.22	0	0.02	0.01
688	-1.58	-2.88	-8.71	0.924	0.853	16.9	-3.8	-6.07	36	-0.19	0	0.02	0.01
689	-1.58	-2.89	-9.21	0.969	0.866	14.4	-3.78	-6.26	36	-0.16	0	0.02	0.01
690	-1.57	-2.89	-9.7	1.03	0.875	11.8	-3.8	-6.49	36	-0.14	0	0.03	0.01
691	-1.54	-2.86	-10.2	1.1	0.877	9.09	-3.82	-6.76	35.9	-0.11	0	0.03	0.01
692	-1.44	-2.79	-10.6	1.18	0.868	6.32	-3.85	-7.07	36	-0.08	0	0.03	0.01
693	-1.27	-2.63	-11	1.26	0.847	3.43	-3.86	-7.39	35.9	-0.05	0	0.03	0.01
694	-0.992	-2.38	-11.3	1.35	0.81	0.41	-3.87	-7.72	36	0.01	0	0.03	0.01
695	-0.569	-1.99	-11.4	1.44	0.748	-2.73	-3.86	-8.04	36.1	0	0	0.02	0.01
696	0.0388	-1.4	-11.2	1.52	0.653	-5.97	-3.83	-8.33	36.1	0	0	0.02	0.01
697	0.87	-0.562	-10.7	1.58	0.506	-9.3	-3.76	-8.55	35.9	0	0	0.02	0.01
698	1.93	0.618	-9.71	1.61	0.28	-12.7	-3.62	-8.65	36	0	0	0.02	0
699	3.11	2.2	-8.22	1.54	-0.0664	-16	-3.4	-8.53	36.1	0	0	0.02	0
700	4.01	4.21	-6.28	1.24	-0.592	-19.2	-3.17	-8.09	35.9	0	0	0.02	0.01
701	3.56	6.42	-4.38	0.516	-1.38	-21.8	-3.56	-7.18	36	0	0.01	0.01	0.03
702	-0.404	8.02	-4.05	-0.837	-2.75	-22	-6.34	-5.12	36	0	0	0.01	0.07
703	-11.3	5.31	-9.89	-2.31	-7.32	-13.2	-9.16	2.77	36	0	0	0.03	0.1
704	-21	3.16	-19.2	0.227	3.12	-1.72	2.7	13.1	36	0.16	0.06	0.01	0.07
705	-11.2	-9.01	-9.52	4.44	-7.54	-0.911	3.24	6.97	18	0.2	0.21	0.24	0.4
706	-4.33	-12.7	-13.1	0.841	0.761	-0.102	-4.07	3.05	18	0.08	0.19	0.05	0.04
707	-2.65	-17.1	-11.7	-1.25	4.56	-0.426	-7.1	1.47	18	0.04	0.24	0.07	0.24

D-95

✓NRH

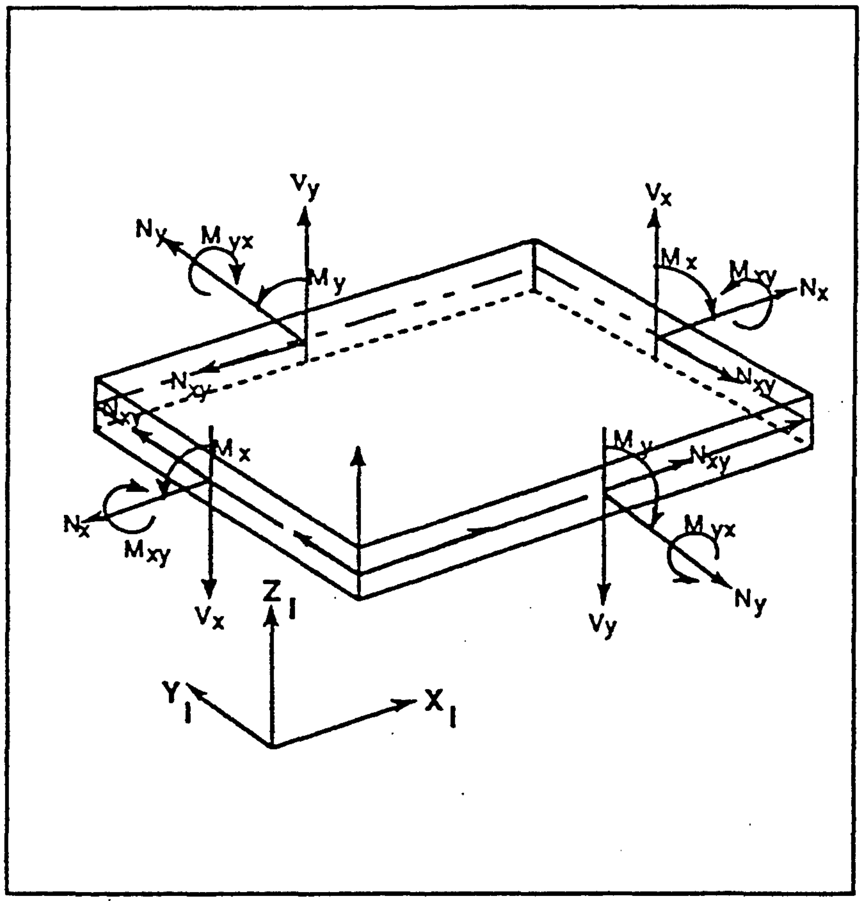
DMT
Pg 43

DMT
2-11-92
Pg 44

✓NRH
4-8-92

708	-3.42	-21	-9.35	-1.65	6.9	-0.817	-8.06	0.672	18	0.05	0.31	0.09	0.37
709	-4.66	-24.3	-6.97	-1.39	8.22	-1.06	-8.27	0.27	18	0.07	0.37	0.08	0.44
710	-5.53	-26.9	-4.73	-0.948	8.87	-1.07	-8.28	0.0653	18	0.09	0.42	0.05	0.47
711	-5.57	-28.8	-2.42	-0.33	8.99	-0.733	-8.26	-0.178	18	0.1	0.46	0.02	0.48
712	-3.95	-30.9	0.3	0.809	8.16	0.11	-7.66	-1.04	18	0.08	0.51	0.04	0.43
713	-0.51	-37	3.03	1.26	4.74	1.02	-3.74	-3.08	18.1	0.02	0.67	0.07	0.25
714	-5.27	-63.3	6.11	-13.1	23.2	-3.79	-4.08	1.79	18	0.05	1.2	0.69	1.18

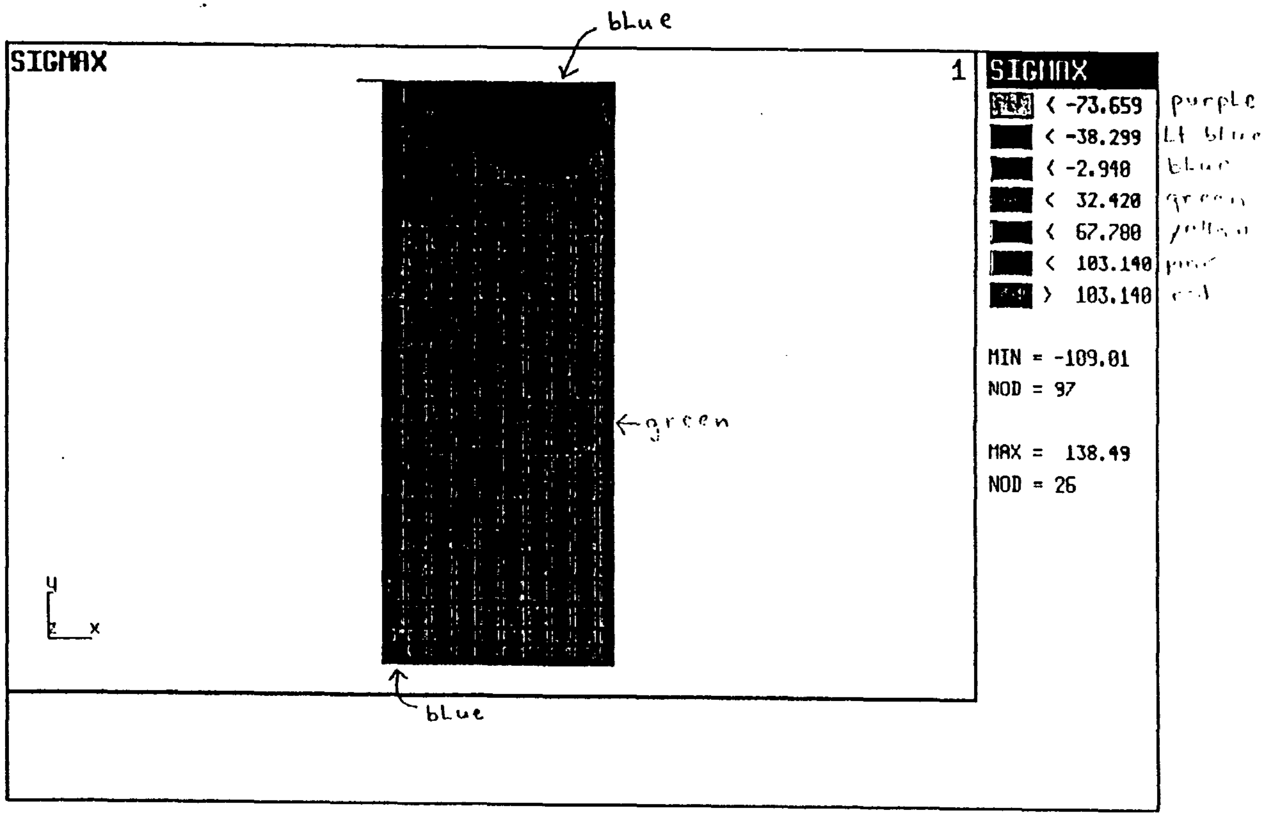
ELEMENT	MX	MY	MXY	VX	VY	NX	NY	NXY	TH	ASX	ASY	VXRAT	VYRAT
715	9.98	0.555	-4.09	1.55	-0.334	1.36	-0.566	-0.098	18	0.2	0	0.08	0.02
716	8.08	0.601	-3.41	0.868	-0.353	0.912	-0.534	-0.178	18	0.16	0	0.05	0.02
717	4.95	0.718	-2.67	0.192	-0.446	0.463	-0.504	-0.0877	18	0.1	0.01	0.01	0.02
718	1.46	0.979	-1.47	-0.579	-0.136	0.162	-0.746	0.0711	18	0.03	0.01	0.03	0.01
718	0.682	0.418	-0.655	-0.272	-0.0582	0.162	-0.749	0.0524	18	0.02	0	0.02	0



Direction of Forces and Stress Components output by COSMOS/M

Figure 2–16. Thick Shell Element

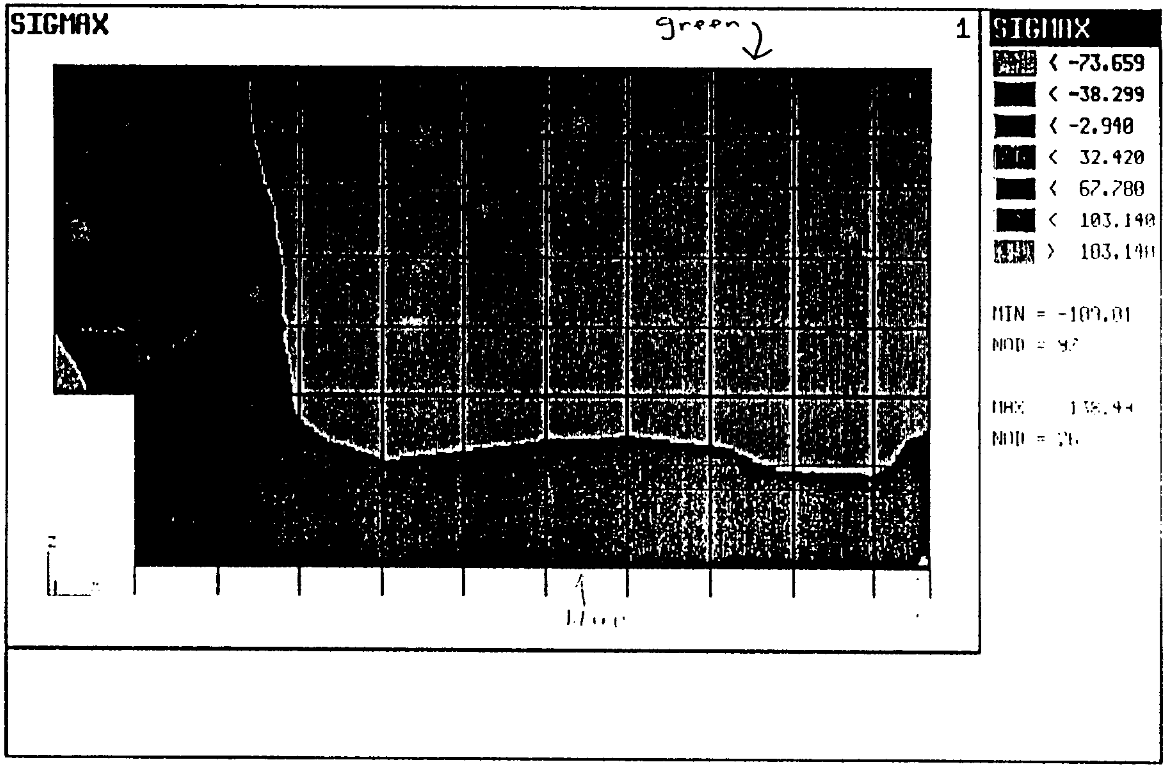
x-rot = 0°
y-rot = 0°
z-rot = 0°



Slab Stresses

4-8-92

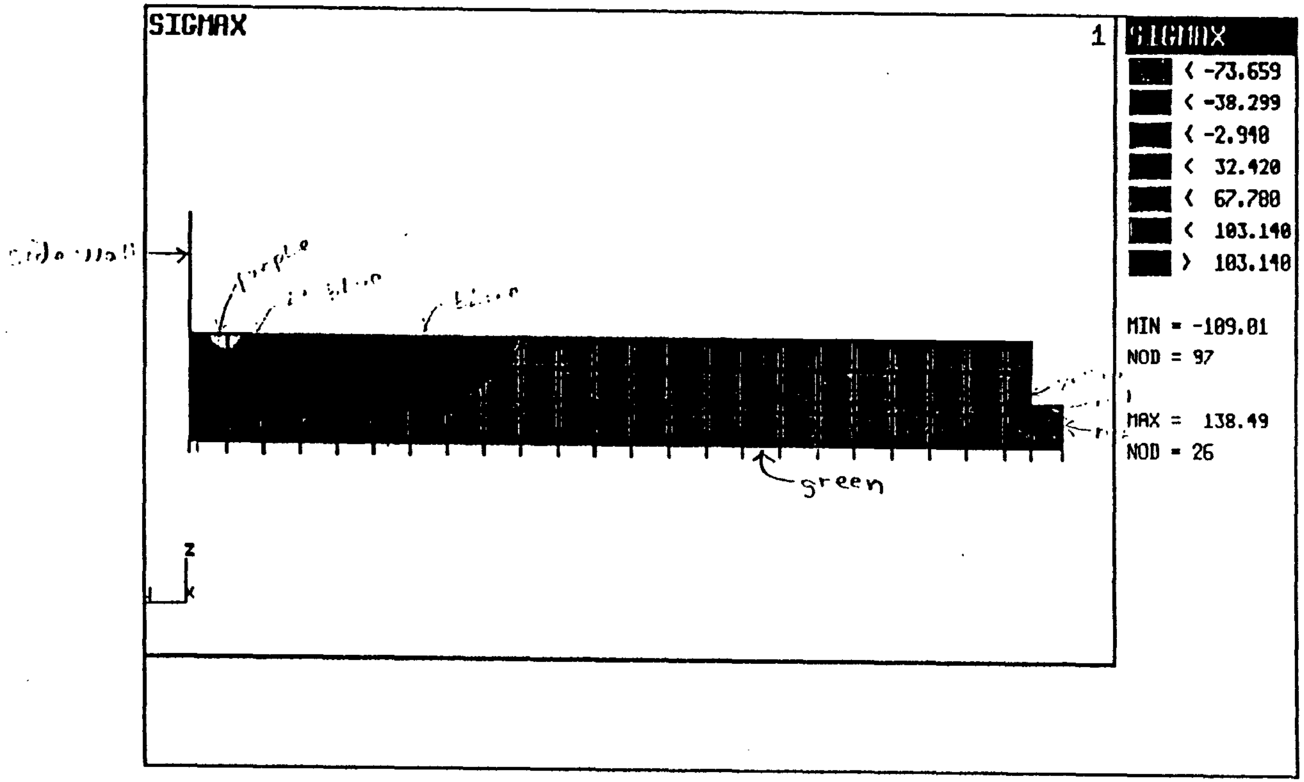
2-11-92
x-rot. = -90°
y-rot = 0
z-rot = 0



Side Wall Stresses

/NRH
4-8-92

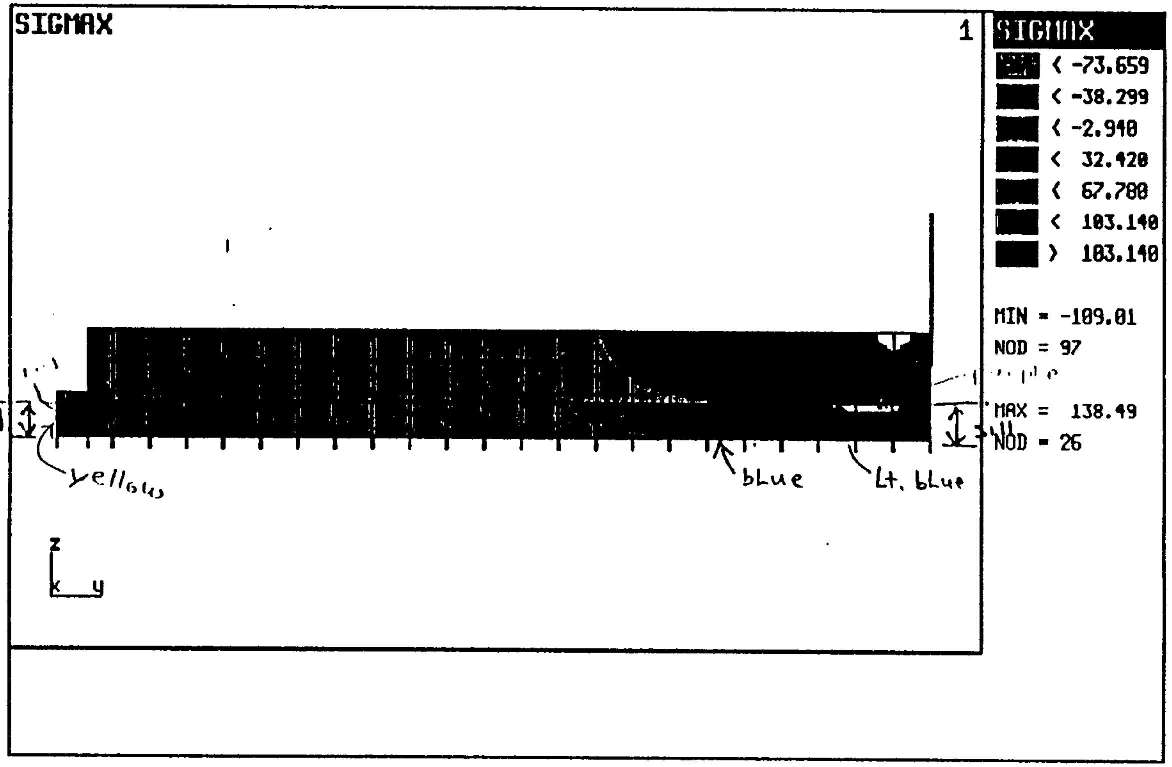
x-rot = -90°
y-rot = 0
z-rot. = -90°



Drop Wall Stresses
(Looking D/S)

✓NRH
4-8-92

DMT
2-11-92
X-rot = -90°
Y-rot = 0
Z-rot = -90°



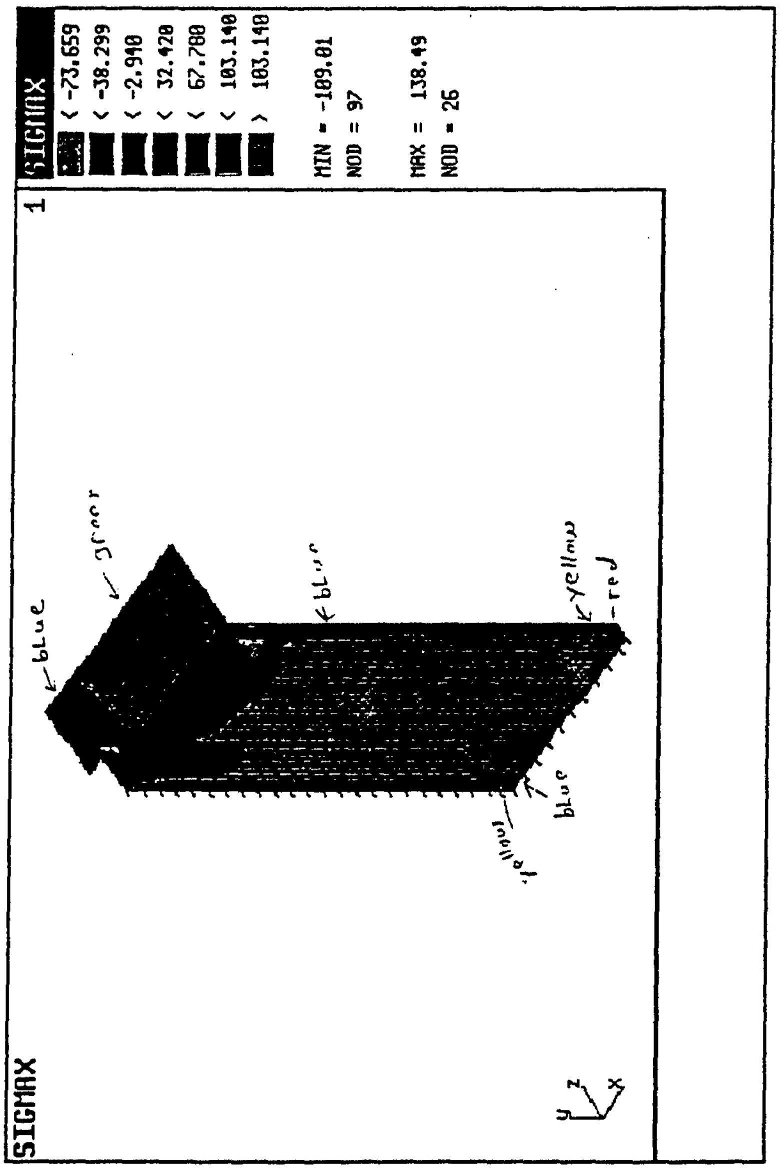
Sill wall stresses
(Looking U/S)

✓NRH
4-8-92

Pg 49

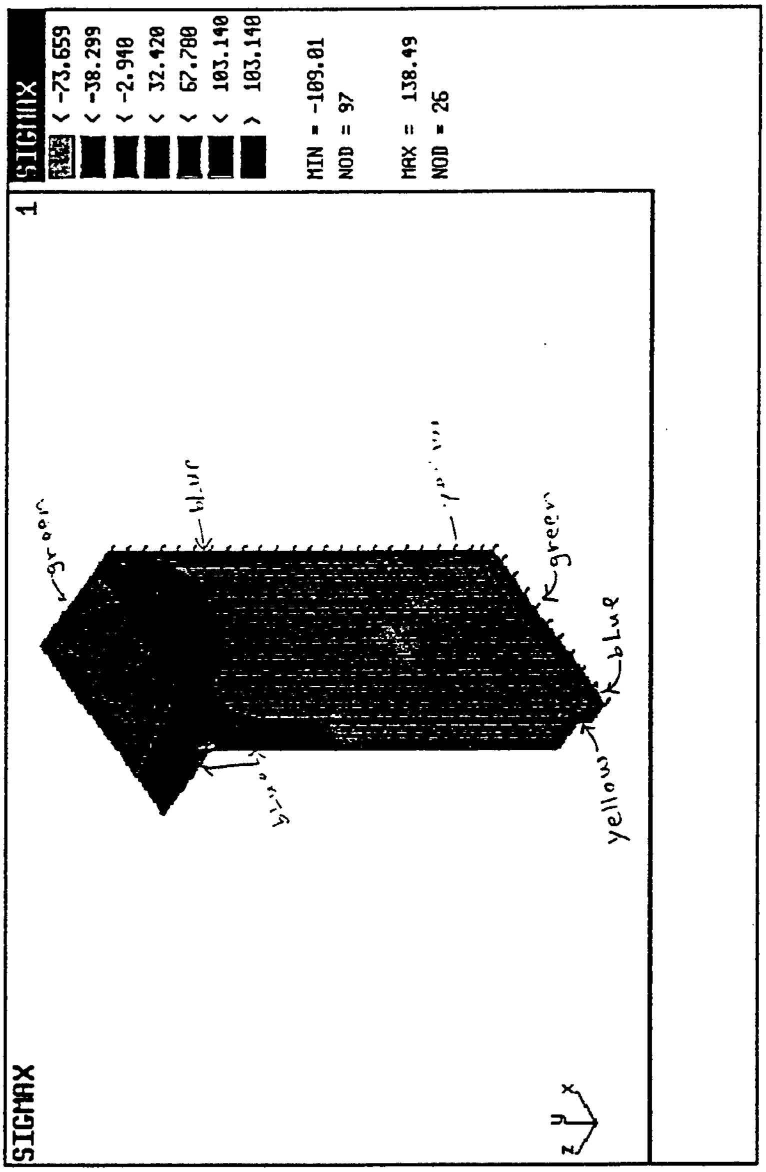
x-rot = -45°
y-rot = 45°
z-rot = 0°

✓NRH
4-8-92



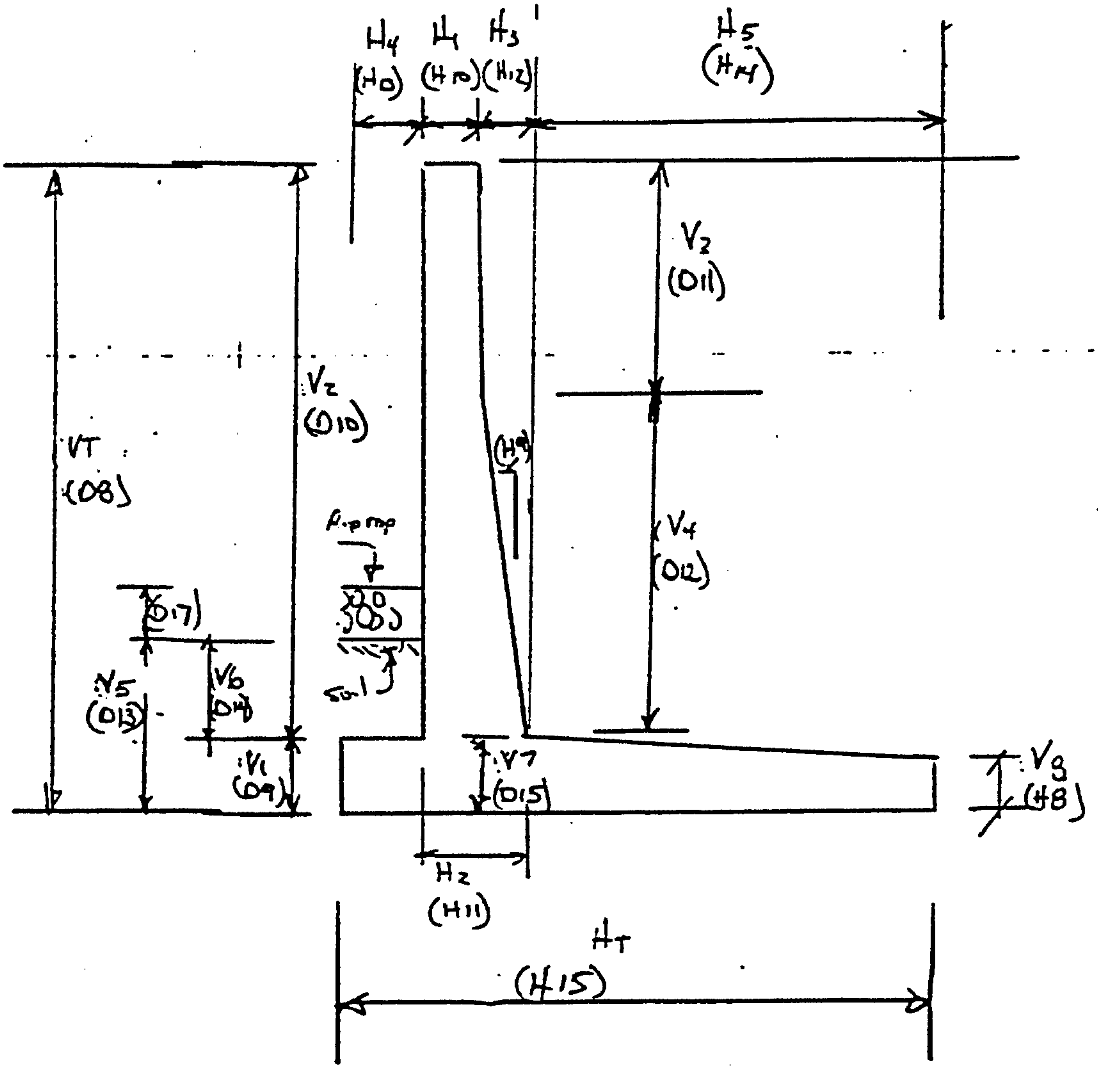
DMI
2-11-92
x-rot = -45°
y-rot = -45°
z-rot = 0

✓NRH
4-8-92



COMPUTER INPUT

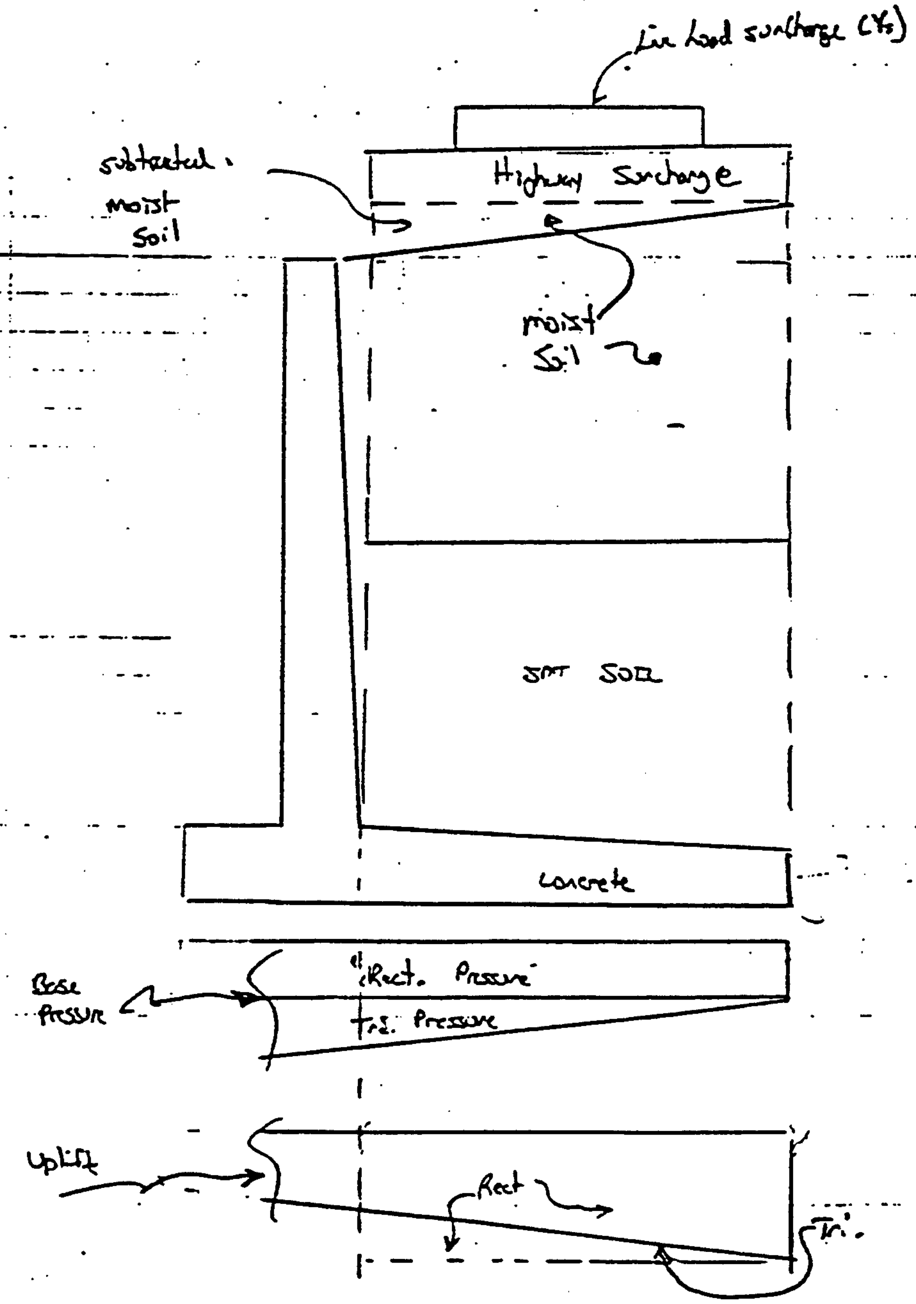
WALL SECTION PROPERTIES



ALL DIMENSIONS IN FEET

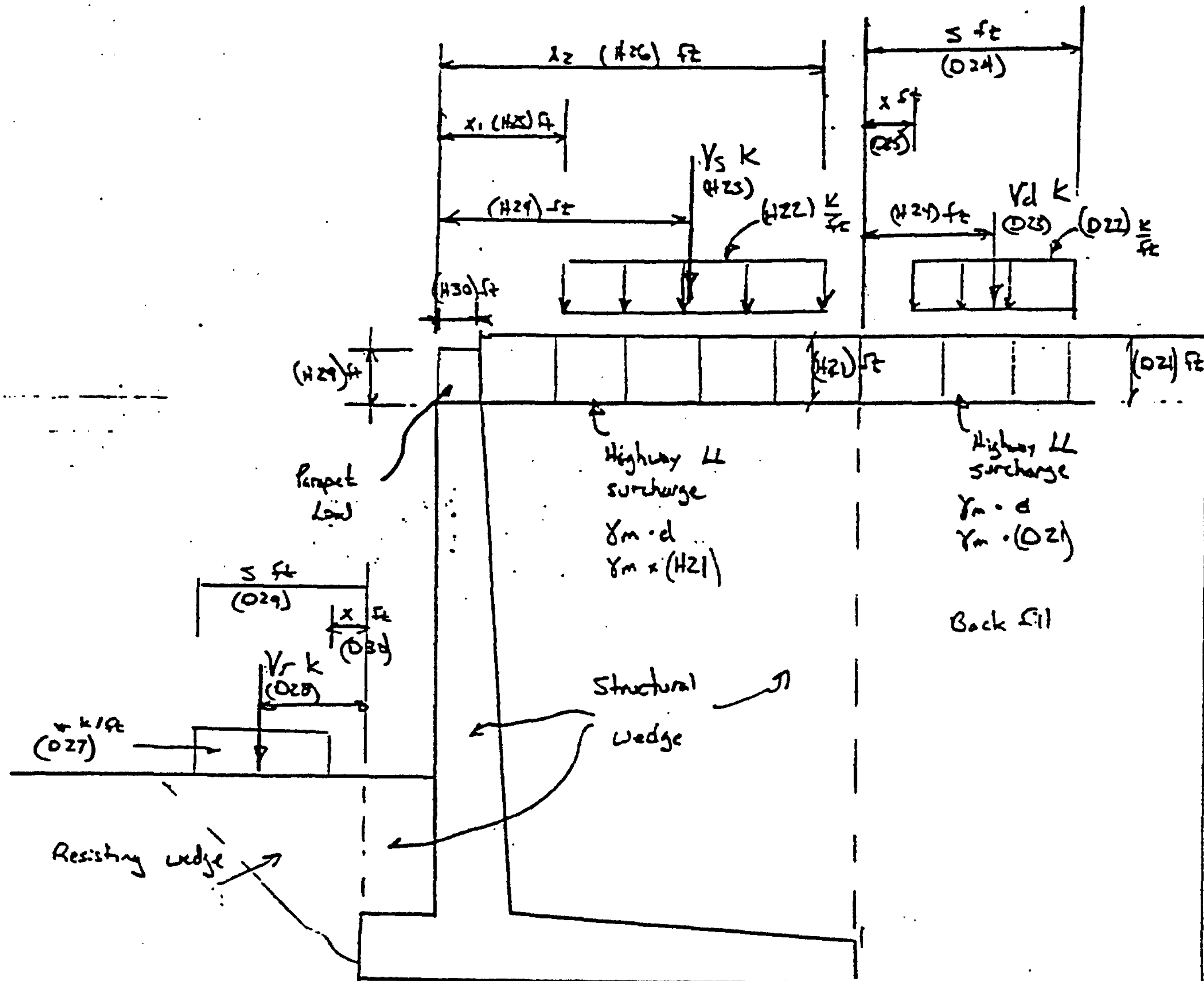
KENT HOKENS
COMPUTER INPUT

HEEL REINFORCING STEEL DESIGN



COMPUTER INPUT

ADDITIONAL VERTICAL LOADS



MAR 9 1992

THE COMPUTATIONS IN THIS VOLUME WERE CHECKED INDE-PENDENTLY TO THE SATISFACTION OF REVIEWER. (BEAR CREEK / 6TH ST SE)

Harry Schueller

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

Computed by CWB
Checked by BGS
02/11/92
MAR 4 1992

RETAINING WALL DESIGN

BASED ON ENGINEER MANUAL EM 1110-2-2502
VERSION WITH RESISTING SOIL CHECK

WALL SECTION PROPERTIES

TOTAL HEIGHT,VT (FT.)	17.000	HEEL DEPTH @ BACK,V8 (FT)	1.500
FOOTING DEPTH TOE,V1 (FT.)	2.000	STEM BATTER	0.0625
STEM HEIGHT,V2 (FT.)	15.000	WALL WIDTH AT TOP,H1 (FT.)	1.500
STRAIGHT WALL HT.,V3 (FT.)	15.000	WALL WIDTH AT BOT.,H2 (FT.)	1.500
SLOPED WALL HT., V4 (FT.)	0.000	WALL SLOPE,H3 (FT.)	0.000
B.O.F. TO T.O.S., V5 (FT.)	3.000	FOOTING TOE WIDTH,H4 (FT.)	2.000
SOIL DEPTH, V6 (FT.)	1.000	FOOTING HEEL WIDTH,H5 (FT.)	10.000
FOOTING DEPTH HEEL, V7(FT)	2.000	FOOTING WIDTH,HT (FT.)	13.500
		UNIT WEIGHT CONC.,(K/CUFT)	0.150
DEPTH OF RIPRAP IN CHANNEL	0.000	UNIT WEIGHT RIPRAP,(K/CUFT)	0.135

ADDITIONAL VERTICAL LOADS

LOADS ON BACKFILL		LOADS ON STRUCTURAL WEDGE ***	
HIGHWAY L.L. SURCHARGE	0.700 FT	HIGHWAY L.L. SURCHARGE	0.000 FT
LIVE LOAD SURCHARGE (vd)*	0.000 K/FT	LIVE LOAD SURCHARGE	0.000 K/FT
Vd =	0.000 K	SURCHARGE (Vs)	0.000 K
SURCHARGE LOCATION S =	-0.750 FT	DIST. TO F. WALL FACE	6.125 FT
(DRIVING WEDGE) X =	0.000 FT	SURCHARGE LOCATION X1=	1.500 FT
LOADS ON RESISTING WEDGE		FROM F. FACE OF WALL X2=	10.750 FT
LIVE LOAD SURCHARGE (vr)**	0.000 K/FT		
Vr =	0.000 K	PARAPET LOAD	
SURCHARGE LOCATION S =	0.000 FT	- HEIGHT	0.000 FT
(RESISTING WEDGE) X =	0.000 FT	- WIDTH	0.000 FT

* A CHECK IS MADE TO DETERMINE IF THE SURCHARGE ON THE BACKFILL WILL LIE WITHIN THE INFLUENCE OF THE DRIVING WEDGE.

** IT IS CONSERVATIVE TO NEGLECT SURCHARGES Vr AND Vs. IF INCLUDED ASSURE THEY WILL STAY IN PLACE FOR THE CONDITION ANALYZED.

*** THESE LOADS ARE ASSUMED TO ACT ON THE BACKFILL SIDE OF WALL ONLY.

STABILITY REQUIREMENTS

LOADING CONDITIONS CASE ------> R1

% OF PASSIVE PRESSURE USED	50	SLIDING SAFETY FACTOR	1.50
MIN. BASE AREA IN COMPRESS.	100	BEARING CAP. SAFETY FACTOR	2.50

SOIL PROPERTIES (DRIVING WEDGE)

FRICTION ANGLE OF SOIL (01)	33.000 DEG.,(DRIVING WEDGE)	
FRICTION ANGLE OF SOIL (02)	33.000 DEG.,(STRUCT. WEDGE)	
SLOPE OF BACKFILL RISE/RUN	0.000	
BETA ANGLE (B1)	0.000 DEG.	
POINT AT WHICH BACKFILL SLOPE BEGINS	2.00	1=SLOPE BEGINS @ STEM
SOIL DEPTH BACK of HEEL(Hz)	17.000	2=SLOPE BEGINS@BACK OF HEEL
STR. MOBILIZATION FACTOR	0.667 (SMF)	
SOIL UNIT Wt.,MOIST (§ml)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§sl)	0.1250 K/CUFT	{ENTER §ml IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b1)	0.0706 K/CUFT	
DEPTH OF CRACK (dc)	0.000 FT.	
COHESION ON SLIP PLANE C=	0.000 KSF	
COHESION ON SLIP PLANE Cd=	0.000 KSF(DEVELOPED)	= Cd = (SMF)*C

SOIL OR DRAINAGE FILL PROPERTIES (FOUNDATION MATERIAL)

FRICTION ANGLE OF SOIL (Of)	35.000 DEG.	(USED FOR BEARING CAPACITY)
FRICTION ANGLE FOR SLIDING	30.000 DEG.	(USED FOR SLIDING ANALYSIS)

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 4 1992
CW
B65

FOUNDATION MATERIAL	2.000 <————————	1 = SOIL FOUNDATION
SOIL UNIT Wt.,MOIST (§m2)	0.130 K/CUFT	2 = ROCK FOUNDATION
SOIL UNIT Wt.,SATUR. (§s2)	0.137 K/CUFT	{ENTER §m2 IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b2)	0.0745 K/CUFT	
COHESION OF FOUNDATION Cfs=	0.000 KSF	(USED FOR SLIDING ANALYSIS)
LENGTH OF COHESION, C1=	13.500 FT	

UNDERLYING ROCK PROPERTIES

ROCK UNIT Wt., (§r2)	0.1600 K/CUFT	
COHESION OF FOUNDATION Cfr=	7.200 KSF	(USED FOR BEARING CAPACITY)

SOIL PROPERTIES (RESISTING WEDGE)

FRICTION ANGLE OF SOIL (03)	33.000 DEG.	
SLOPE OF OVERLAY,RISE/RUN	-0.300	
BETA ANGLE (B3)	-16.699 DEG.	
SOIL DEPTH TOE SIDE	3.000 FT.	
SOIL UNIT Wt.,MOIST (§m3)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§s3)	0.1250 K/CUFT	{ENTER §m3 IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b3)	0.0545 K/CUFT	
COHESION ON SLIP PLANE Cr=	0.000 KSF	

WATER PRESSURE PROPERTIES

SATURATION HT. BACKSIDE(h1)	2.00	DIFFERENTIAL HEAD(<h) =	2.00
SATURATION HT.FRONT (h2)	0.00	WATER Ht. ABOVE	
HEIGHT OF MOIST SOIL (hm)	15.00	WATER Ht. IN STREAM(hw)	0.00
WATER UNIT WEIGHT (§w)	0.0625 K/CUFT		

STRUCTURAL CONCRETE PROPERTIES

CONC. STRENGTH (KSI) f'c=	4.00	COVER TO C.G. REINF.(IN)	
REINF.STR.(KSI)fy=	60.00	STEM =	3.50
LOAD FACTOR	2.21	HEEL =	3.50
STR. REDUCT FACTOR	0.90 (MOMENT)	TOE =	4.50
STR. REDUCT FACTOR	0.85 (SHEAR)	p max =	0.00713
WALL INCREMENT (FT)	1.00	p min =	0.00333

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 4 1992
CWB
BGS

SUMMATION OF MOMENTS ABOUT THE TOE

AREA	VERT.	HORIZ.	WIDTH (FT)	UNIT WT. (K/CU.FT)	P VERT. (K/FT)	D (ARM)	M (FT-kips)
1	15.000	1.500	1.000	0.150	3.375	2.750	9.28
2	0.000	0.000	1.000	0.150	0.000	3.500	0.00
3	2.000	3.500	1.000	0.150	1.050	1.750	1.84
4	1.750	10.000	1.000	0.150	2.625	8.262	21.69
5	1.000	2.000	1.000	0.120	0.240	1.000	0.24
5A	0.000	2.000	1.000	0.125	0.000	1.000	0.00
5B	0.000	2.000	1.000	0.135	0.000	1.000	0.00
5C	0.000	2.000	1.000	0.063	0.000	1.000	0.00
6	15.000	0.000	1.000	0.120	0.000	3.500	0.00
6A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
7	0.000	0.000	1.000	0.120	0.000	0.000	0.00
7A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
8	15.000	10.000	1.000	0.120	18.000	8.500	153.00
8A	0.000	10.000	1.000	0.125	0.000	8.500	0.00
9	0.500	5.000	1.000	0.125	0.313	10.167	3.18
10	0.000	5.000	1.000	0.120	0.000	10.167	0.00
PARAPET	0.000	0.000	1.000	0.150	0.000	2.750	0.00
DL TOTAL					25.603	7.391	189.22

	P HOR.	P VERT.		
HORIZONTAL WEDGE LOADS:	P HOR.	P VERT.		
L.E.P. SOIL (DRIVING)	-7.437		5.70	-42.35
VERTICAL COMPONENT		0.00	0.00	0.00
LATERAL WATER (DRIVING)	-0.11		0.67	-0.07
SURCHARGE (DRIVING)	0.00		0.00	0.00
L.E.P. SOIL + SURCHARGE (RESISTING)	0.25		1.00	0.25
VERTICAL COMPONENT (NOT COMPUTED)		0.00	0.00	0.00
LATERAL WATER (RESISTING)	0.000		0.00	0.00
UPLIFT		-0.74	9.00	-6.62
SUBTOTAL ——>	-7.30	24.87	5.65	140.4
ADDITIONAL LOADS				
HIGHWAY L.L. SURCHARGE - FM BACKFILL	-0.62		8.50	-5.24
- VERT. ON STRUCTURAL WEDGE		0.00	8.500	0.00
SURCHARGE (STRUCTURAL WEDGE - Vs)		0.00	8.13	0.00
TOTAL ——>	-7.92	24.87	5.44	135.19

TOTAL WEIGHT OF STRUCTURAL WEDGE = 24.87 kips

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 4 1992

CWB

BGS

OVERTURNING STABILITY ANALYSIS

Xr= SUM MOMENT ABOUT TOE/SUM OF VERTICAL FORCES
SUM MOM= 135.2 F-kips
Pvert = 24.87 kips $\bar{X}$ = 5.44 FT.

ECCENTRICITY e= HT/2-$\bar{X}$ = 1.31 < 2.25 = HT/6

% BASE IN COMP.= 3*X/HT =" 100.0 %

CRITERIA SATISFIED

SLIDING STABILITY ANALYSIS

N' = Vsum =	24.87 kips	T = Hsum =	7.92 kips
0 = 30.00	L = % BASE IN COMPRESSION * HT =		13.50
C = 0.00		FS =	1.50

N'*TAN0/FS (NO COHESION INCLUDED) = 9.57 kips

RESISTING SOIL FORCE REQUIRED = 0.00 kips

ALLOW. PASSIVE SOIL + SURCHARGE = 0.37 kips
AT REST SOIL + SURCHARGE = 0.25 kips

FS = 1.81 -> SLIDING CRITERIA IS SATISFIED

CHECK BEARING CAPACITY

BEARING CAPACITY = Q EQU. 5-2
Q= $\bar{B}$[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB(§m-f)Nr)/2]

ECCEN. OF LOAD e= 1.31

EFFECTIVE WIDTH OF BASE $\bar{B}$= HT-2e = 10.87

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502
Nq = 33.30
Nc = 46.12
Nr = 37.15

EMBEDMENT FACTORS

Ecd =1+0.2(V5/$\bar{B}$)TAN(45+0/2) =	1.102	EQU.5-4a	
Eqd=Erd =	1.000	EQU.5-4b	IF(0 = 0)
Eqd=Erd =1+0.1(V5/$\bar{B}$)TAN(45+0/2) =		EQU.5-4c	IF(0 >10)
Eqd=Erd =	1.051	FOR (0<0<=10)	

INTERPOLATE BETWEEN EQU. 5-4b AND 4c

INCLINATION FACTORS

§o = ARCTAN[(SUM H)/SUM V] = 17.66 DEG.
Eqi=Eci =(1-§o/90)^2 = 0.646 EQU.5-5a
Eri =IF §o > FRIC. ANGLE(0) THEN Eri = 0, ELSE,
Eri =(1-§o/0)^2 = 0.246 EQU.5-5b

BASE TILT FACTORS (A2 IN RADIANS)

Eqt=Ert =(1-a2*TAN0)^2 = 1.000 EQU.5-6a
Ect =1-(2*a2/PI+2) EQU.5-6b (IF 0 =0)
Ect =Eqt-[(1-Eqt)/(NcTAN0)] EQU.5-6c (IF 0 >0)
Ect = 1.000

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT MAR 4 1992

CWB
B65

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GROUND SLOPE FACTORS
        Erg=Eqg =[1-TAN(-B3)]^2 =              0.490 EQU.5-7a
            Ecg =1-[2*(-B3)/(PI+2)]  (B3 IN RAD.)    EQU.5-7b (IF 0 =0)
            Ecg =Eqg-[(1-Eqg)/Nc*TAN0]               EQU.5-7d (IF 0 >0)
            Ecg =                              0.483

EFFECTIVE OVERBURDEN PRESSURE
             qo =(§3*V5+RIPRAP)*COS/B3/ =      0.345 EQU.5-8a

                  BEARING CAPACITY = 1309.41 kips    EQU. 5-2
                                     ---------
                   F.O.S. =Q/SUM V=      52.7        EQU. 5-1
                                     ---------
                           BEARING CAPACITY IS SATISFIED
```

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                        BASE PRESSURES DISTRIBUTION (FOOTING)
                        --------------------------
    p1= P/HT*(1+6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
    p1 =2*P/{3*(HT/2-e)} =      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING

    p2= P/HT*(1-6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
    p2 = 0                      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING
                                  DISTANCE TO p2   =     13.50 FT

            p1 =   2.9173 KSF          p2 =   0.7667 KSF
```

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 4 1992
CWR
13

STEM DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI) f'c= 4.00 REINF.STR.(KSI)fy= 60.00

COVER TO C.G. REINF.(IN) 3.50 LOAD FACTOR 2.21
WALL INCREMENT (FT) 1.00 STR. REDUCT FACTOR 0.90
As max based on p max = 1.24 in^2 MAX CRACK MOMENT 25.61

DISTANCE ABOVE FT TOP (FT)	WALL THICK. (IN)	d (IN)	ULT. MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
0.00	18.00	14.50	73.33	1.20	0.58	0.19	1.20
1.00	18.00	14.50	60.16	0.97	0.58	0.19	0.97
2.00	18.00	14.50	48.65	0.78	0.58	0.19	0.78
3.00	18.00	14.50	38.71	0.61	0.58	0.19	0.61
4.00	18.00	14.50	30.22	0.47	0.58	0.19	0.58
5.00	18.00	14.50	23.07	0.36	0.58	0.19	0.48
6.00	18.00	14.50	17.14	0.27	0.58	0.19	0.36
7.00	18.00	14.50	12.32	0.19	0.58	0.19	0.25
8.00	18.00	14.50	8.50	0.13	0.58	0.19	0.19
9.00	18.00	14.50	5.56	0.09	0.58	0.19	0.19
10.00	18.00	14.50	3.38	0.05	0.58	0.19	0.19
11.00	18.00	14.50	1.86	0.03	0.58	0.19	0.19
12.00	18.00	14.50	0.88	0.01	0.58	0.19	0.19
13.00	18.00	14.50	0.31	0.00	0.58	0.19	0.19
14.00	18.00	14.50	0.06	0.00	0.58	0.19	0.19
15.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
16.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
17.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
18.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
19.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
20.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
21.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
22.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (STEM)

STR. RED FACTOR 0= 0.85 Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 2/3*0*Vc ACI 12.10.5.1
AT CUT OF POINT

DISTANCE ABOVE FT BOTT (FT)	WALL THICK. (IN)	D (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
0.00	18.00	14.50	14.01	22.01	18.71

CWB
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HEEL DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	1.00	LOAD FACTOR	2.21
COVER TO C.G. REINF.(IN)	3.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.75 in^2	MAX CRACK MOMENT	45.54

DISTANCE FROM HEEL BACK (FT)	HEEL THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
10.000	24.00	20.50	78.67	0.88	0.82	0.26	0.88
9.000	23.40	19.90	68.20	0.78	0.80	0.25	0.80
8.000	22.80	19.30	57.42	0.68	0.77	0.25	0.77
7.000	22.20	18.70	46.67	0.57	0.75	0.24	0.75
6.000	21.60	18.10	36.28	0.45	0.72	0.23	0.60
5.000	21.00	17.50	26.57	0.34	0.70	0.23	0.46
4.000	20.40	16.90	17.89	0.24	0.68	0.22	0.32
3.000	19.80	16.30	10.56	0.14	0.65	0.21	0.21
2.000	19.20	15.70	4.91	0.07	0.63	0.21	0.21
1.000	18.60	15.10	1.28	0.02	0.60	0.20	0.20
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (HEEL)

STR. RED FACTOR 0=	0.85	Vc = 2*(f'c)^.5*b*d	ACI EQU.(11-3)
		ULT.SHEAR < 0*Vc	ACI 12.10.5.1

DISTANCE U BACK (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
10.00	24.00	20.50	10.21	31.12	26.45

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT MAR 4 199

CW
BC

TOE DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	0.50	LOAD FACTOR	2.21
COVER TO C.G. REINF.(IN)	4.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.67 in^2	MAX CRACK MOMENT	45.54

DISTANCE FROM TOE (FT)	TOE THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
2.00	24.00	19.50	11.12	0.13	0.78	0.26	0.26
1.50	24.00	19.50	6.32	0.07	0.78	0.26	0.26
1.00	24.00	19.50	2.84	0.03	0.78	0.26	0.26
0.50	24.00	19.50	0.72	0.01	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26

CHECK SHEAR (TOE)

STR. RED FACTOR 0= 0.85 Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 0*Vc ACI 12.10.5.1

DISTANCE FROM TOE (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
2.00	24.00	19.50	10.90	29.60	25.16

MAR 4 1992
CWB
265

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

RETAINING WALL DESIGN 02/11/92

BASED ON ENGINEER MANUAL EM 1110-2-2502
VERSION WITH RESISTING SOIL CHECK

WALL SECTION PROPERTIES

TOTAL HEIGHT,VT (FT.)	17.000	HEEL DEPTH @ BACK,V8 (FT)	1.500
FOOTING DEPTH TOE,V1 (FT.)	2.000	STEM BATTER	0.0625
STEM HEIGHT,V2 (FT.)	15.000	WALL WIDTH AT TOP,H1 (FT.)	1.500
STRAIGHT WALL HT.,V3 (FT.)	15.000	WALL WIDTH AT BOT.,H2 (FT.)	1.500
SLOPED WALL HT., V4 (FT.)	0.000	WALL SLOPE,H3 (FT.)	0.000
B.O.F. TO T.O.S., V5 (FT.)	3.000	FOOTING TOE WIDTH,H4 (FT.)	2.000
SOIL DEPTH, V6 (FT.)	1.000	FOOTING HEEL WIDTH,H5 (FT.)	10.000
FOOTING DEPTH HEEL, V7(FT)	2.000	FOOTING WIDTH,HT (FT.)	13.500
		UNIT WEIGHT CONC.,(K/CUFT)	0.150
DEPTH OF RIPRAP IN CHANNEL	0.000	UNIT WEIGHT RIPRAP,(K/CUFT)	0.135

ADDITIONAL VERTICAL LOADS

LOADS ON BACKFILL		LOADS ON STRUCTURAL WEDGE ***	
HIGHWAY L.L. SURCHARGE	2.000 FT	HIGHWAY L.L. SURCHARGE	0.000 FT
LIVE LOAD SURCHARGE (vd)*	0.000 K/FT	LIVE LOAD SURCHARGE	0.000 K/FT
Vd =	0.000 K	SURCHARGE (Vs)	0.000 K
SURCHARGE LOCATION S =	-0.750 FT	DIST. TO F. WALL FACE	6.125 FT
(DRIVING WEDGE) X =	0.000 FT	SURCHARGE LOCATION X1=	1.500 FT
LOADS ON RESISTING WEDGE		FROM F. FACE OF WALL X2=	10.750 FT
LIVE LOAD SURCHARGE (vr)**	0.000 K/FT		
Vr =	0.000 K	PARAPET LOAD	
SURCHARGE LOCATION S =	0.000 FT	- HEIGHT	0.000 FT
(RESISTING WEDGE) X =	0.000 FT	- WIDTH	0.000 FT

* A CHECK IS MADE TO DETERMINE IF THE SURCHARGE ON THE BACKFILL WILL LIE WITHIN THE INFLUENCE OF THE DRIVING WEDGE.

** IT IS CONSERVATIVE TO NEGLECT SURCHARGES Vr AND Vs. IF INCLUDED ASSURE THEY WILL STAY IN PLACE FOR THE CONDITION ANALYZED.

*** THESE LOADS ARE ASSUMED TO ACT ON THE BACKFILL SIDE OF WALL ONLY.

STABILITY REQUIREMENTS

LOADING CONDITIONS CASE ——>	R2		
% OF PASSIVE PRESSURE USED	50	SLIDING SAFETY FACTOR	1.33
MIN. BASE AREA IN COMPRESS.	75	BEARING CAP. SAFETY FACTOR	2.00

SOIL PROPERTIES (DRIVING WEDGE)

FRICTION ANGLE OF SOIL (01)	33.000	DEG.,(DRIVING WEDGE)
FRICTION ANGLE OF SOIL (02)	33.000	DEG.,(STRUCT. WEDGE)
SLOPE OF BACKFILL RISE/RUN	0.000	
BETA ANGLE (B1)	0.000	DEG.
POINT AT WHICH BACKFILL SLOPE BEGINS	2.00	1=SLOPE BEGINS @ STEM
SOIL DEPTH BACK of HEEL(Hz)	17.000	2=SLOPE BEGINS@BACK OF HEEL
STR. MOBILIZATION FACTOR	0.750	(SMF)
SOIL UNIT Wt.,MOIST (§ml)	0.1200	K/CUFT
SOIL UNIT Wt.,SATUR. (§s1)	0.1250	K/CUFT (ENTER §ml IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b1)	0.0794	K/CUFT
DEPTH OF CRACK (dc)	0.000	FT.
COHESION ON SLIP PLANE C=	0.000	KSF
COHESION ON SLIP PLANE Cd=	0.000	KSF(DEVELOPED) = Cd = (SMF)*C

SOIL OR DRAINAGE FILL PROPERTIES (FOUNDATION MATERIAL)

FRICTION ANGLE OF SOIL (Of)	35.000	DEG. (USED FOR BEARING CAPACITY)
FRICTION ANGLE FOR SLIDING	30.000	DEG. (USED FOR SLIDING ANALYSIS)

MAR 4 1992
CWE

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

FOUNDATION MATERIAL	2.000 <———	1 = SOIL FOUNDATION
SOIL UNIT Wt.,MOIST (§m2)	0.130 K/CUFT	2 = ROCK FOUNDATION
SOIL UNIT Wt.,SATUR. (§s2)	0.137 K/CUFT	{ENTER §m2 IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b2)	0.0745 K/CUFT	
COHESION OF FOUNDATION Cfs=	0.000 KSF	(USED FOR SLIDING ANALYSIS)
LENGTH OF COHESION, C1=	13.500 FT	

UNDERLYING ROCK PROPERTIES

ROCK UNIT Wt., (§r2)	0.1600 K/CUFT	
COHESION OF FOUNDATION Cfr=	7.200 KSF	(USED FOR BEARING CAPACITY)

SOIL PROPERTIES (RESISTING WEDGE)

FRICTION ANGLE OF SOIL (03)	33.000 DEG.	
SLOPE OF OVERLAY,RISE/RUN	-0.300	
BETA ANGLE (B3)	-16.699 DEG.	
SOIL DEPTH TOE SIDE	3.000 FT.	
SOIL UNIT Wt.,MOIST (§m3)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§s3)	0.1250 K/CUFT	{ENTER §m3 IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b3)	0.0457 K/CUFT	
COHESION ON SLIP PLANE Cr=	0.000 KSF	

WATER PRESSURE PROPERTIES

SATURATION HT. BACKSIDE(h1)	5.00	DIFFERENTIAL HEAD(<h) =	5.00
SATURATION HT.FRONT (h2)	0.00	WATER Ht. ABOVE	
HEIGHT OF MOIST SOIL (hm)	12.00	WATER Ht. IN STREAM(hw)	0.00
WATER UNIT WEIGHT (§w)	0.0625 K/CUFT		

STRUCTURAL CONCRETE PROPERTIES

CONC. STRENGTH (KSI) f'c=	4.00	COVER TO C.G. REINF.(IN)	
REINF.STR.(KSI)fy=	60.00	STEM =	3.50
LOAD FACTOR	1.66	HEEL =	3.50
STR. REDUCT FACTOR	0.90 (MOMENT)	TOE =	4.50
STR. REDUCT FACTOR	0.85 (SHEAR)	p max =	0.00713
WALL INCREMENT (FT)	1.00	p min =	0.00333

MAR 4 1992
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SUMMATION OF MOMENTS ABOUT THE TOE

AREA	VERT.	HORIZ.	WIDTH (FT)	UNIT WT. (K/CU.FT)	P VERT. (K/FT)	D (ARM)	M (FT-kips)
1	15.000	1.500	1.000	0.150	3.375	2.750	9.28
2	0.000	0.000	1.000	0.150	0.000	3.500	0.00
3	2.000	3.500	1.000	0.150	1.050	1.750	1.84
4	1.750	10.000	1.000	0.150	2.625	8.262	21.69
5	1.000	2.000	1.000	0.120	0.240	1.000	0.24
5A	0.000	2.000	1.000	0.125	0.000	1.000	0.00
5B	0.000	2.000	1.000	0.135	0.000	1.000	0.00
5C	0.000	2.000	1.000	0.063	0.000	1.000	0.00
6	12.000	0.000	1.000	0.120	0.000	3.500	0.00
6A	3.000	0.000	1.000	0.125	0.000	3.500	0.00
7	0.000	0.000	1.000	0.120	0.000	0.000	0.00
7A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
8	12.000	10.000	1.000	0.120	14.400	8.500	122.40
8A	3.000	10.000	1.000	0.125	3.750	8.500	31.88
9	0.500	5.000	1.000	0.125	0.313	10.167	3.18
10	0.000	5.000	1.000	0.120	0.000	10.167	0.00
PARAPET	0.000	0.000	1.000	0.150	0.000	2.750	0.00
DL TOTAL					25.752	7.397	190.50

	P HOR.	P VERT.	D	M
HORIZONTAL WEDGE LOADS:				
L.E.P. SOIL (DRIVING)	-6.580		5.79	-38.08
VERTICAL COMPONENT		0.00	0.00	0.00
LATERAL WATER (DRIVING)	-0.57		1.67	-0.95
SURCHARGE (DRIVING)	0.00		0.00	0.00
L.E.P. SOIL + SURCHARGE (RESISTING)	0.25		1.00	0.25
VERTICAL COMPONENT (NOT COMPUTED)		0.00	0.00	0.00
LATERAL WATER (RESISTING)	0.000		0.00	0.00
UPLIFT		-1.54	9.00	-13.86
SUBTOTAL ——>	-6.90	24.21	5.69	137.9
ADDITIONAL LOADS				
HIGHWAY L.L. SURCHARGE - FM BACKFILL	-1.60		8.50	-13.56
- VERT. ON STRUCTURAL WEDGE		0.00	8.500	0.00
SURCHARGE (STRUCTURAL WEDGE - Vs)		0.00	8.13	0.00
TOTAL ——>	-8.50	24.21	5.13	124.30

TOTAL WEIGHT OF STRUCTURAL WEDGE = 24.21 kips

OVERTURNING STABILITY ANALYSIS

Xr= SUM MOMENT ABOUT TOE/SUM OF VERTICAL FORCES
SUM MOM= 124.3 F-kips
Pvert = 24.21 kips $\bar{X}$ = 5.13 FT.

ECCENTRICITY e= HT/2-$\bar{X}$ = 1.62 < 2.25 = HT/6

% BASE IN COMP.= 3*X/HT =" 100.0 %

CRITERIA SATISFIED

SLIDING STABILITY ANALYSIS

N' = Vsum = 24.21 kips T = Hsum = 8.50 kips
0 = 30.00 L = % BASE IN COMPRESSION * HT = 13.50
C = 0.00 FS = 1.33

N'*TAN0/FS (NO COHESION INCLUDED) = 10.48 kips

RESISTING SOIL FORCE REQUIRED = 0.00 kips

ALLOW. PASSIVE SOIL + SURCHARGE = 0.41 kips
AT REST SOIL + SURCHARGE = 0.25 kips

FS = 1.64 -> SLIDING CRITERIA IS SATISFIED

CHECK BEARING CAPACITY

BEARING CAPACITY = Q EQU. 5-2
Q= $\bar{B}$[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB(§m-f)Nr)/2]

ECCEN. OF LOAD e= 1.62

EFFECTIVE WIDTH OF BASE $\bar{B}$= HT-2e = 10.27

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502
Nq = 33.30
Nc = 46.12
Nr = 37.15

EMBEDMENT FACTORS
Ecd =1+0.2(V5/$\bar{B}$)TAN(45+0/2) = 1.108 EQU.5-4a
Eqd=Erd = = 1.000 EQU.5-4b IF(0 = 0)
Eqd=Erd =1+0.1(V5/$\bar{B}$)TAN(45+0/2) = EQU.5-4c IF(0 >10)
Eqd=Erd = = 1.054 FOR (0<0<=10)
INTERPOLATE BETWEEN EQU. 5-4b AND 4c

INCLINATION FACTORS
§o = ARCTAN[(SUM H)/SUM V] = 19.34 DEG.
Eqi=Eci =(1-§o/90)^2 = 0.616 EQU.5-5a
Eri =IF §o > FRIC. ANGLE(0) THEN Eri = 0, ELSE,
Eri =(1-§o/0)^2 = 0.200 EQU.5-5b

BASE TILT FACTORS (A2 IN RADIANS)
Eqt=Ert =(1-a2*TAN0)^2 = 1.000 EQU.5-6a
Ect =1-(2*a2/PI+2) EQU.5-6b (IF 0 =0)
Ect =Eqt-[(1-Eqt)/(NcTAN0)] EQU.5-6c (IF 0 >0)
Ect = 1.000

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT MAR 4 1992

CWB
265

GROUND SLOPE FACTORS

```
        Erg=Eqg =[1-TAN(-B3)]^2 =                  0.490 EQU.5-7a
            Ecg =1-[2*(-B3)/(PI+2)]  (B3 IN RAD.)        EQU.5-7b (IF 0 =0)
            Ecg =Eqg-[(1-Eqg)/Nc*TAN0]                   EQU.5-7d (IF 0 >0)
            Ecg =                                  0.483
```

EFFECTIVE OVERBURDEN PRESSURE

```
             qo =(§3*V5+RIPRAP)*COS/B3/ =          0.345 EQU.5-8a

              BEARING CAPACITY = 1181.00 kips      EQU. 5-2
                                 ---------
               F.O.S. =Q/SUM V=     48.8           EQU. 5-1
                                 ---------
```

BEARING CAPACITY IS SATISFIED

BASE PRESSURES DISTRIBUTION (FOOTING)

```
    p1= P/HT*(1+6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
    p1 =2*P/(3*(HT/2-e)) =      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING

    p2= P/HT*(1-6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
    p2 = 0                      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING
                                  DISTANCE TO p2    =      13.50 FT

            p1 =    3.0820 KSF          p2 =    0.5050 KSF
```

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13

STEM DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI) f'c=	4.00	REINF.STR.(KSI)fy=	60.00
COVER TO C.G. REINF.(IN)	3.50	LOAD FACTOR	1.66
WALL INCREMENT (FT)	1.00	STR. REDUCT FACTOR	0.90
As max based on p max =	1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE ABOVE FT TOP (FT)	WALL THICK. (IN)	d (IN)	ULT. MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
0.00	18.00	14.50	61.53	0.99	0.58	0.19	0.99
1.00	18.00	14.50	50.94	0.81	0.58	0.19	0.81
2.00	18.00	14.50	41.68	0.66	0.58	0.19	0.66
3.00	18.00	14.50	33.64	0.53	0.58	0.19	0.58
4.00	18.00	14.50	26.70	0.42	0.58	0.19	0.56
5.00	18.00	14.50	20.77	0.32	0.58	0.19	0.43
6.00	18.00	14.50	15.77	0.24	0.58	0.19	0.33
7.00	18.00	14.50	11.63	0.18	0.58	0.19	0.24
8.00	18.00	14.50	8.27	0.13	0.58	0.19	0.19
9.00	18.00	14.50	5.61	0.09	0.58	0.19	0.19
10.00	18.00	14.50	3.57	0.05	0.58	0.19	0.19
11.00	18.00	14.50	2.08	0.03	0.58	0.19	0.19
12.00	18.00	14.50	1.05	0.02	0.58	0.19	0.19
13.00	18.00	14.50	0.42	0.01	0.58	0.19	0.19
14.00	18.00	14.50	0.09	0.00	0.58	0.19	0.19
15.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
16.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
17.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
18.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
19.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
20.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
21.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
22.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (STEM)

STR. RED FACTOR 0= 0.85

Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 2/3*0*Vc ACI 12.10.5.1
AT CUT OF POINT

DISTANCE ABOVE FT BOTT (FT)	WALL THICK. (IN)	D (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
0.00	18.00	14.50	11.27	22.01	18.71

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

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HEEL DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	1.00	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	3.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.75 in^2	MAX CRACK MOMENT	45.54

DISTANCE FROM HEEL BACK (FT)	HEEL THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
10.000	24.00	20.50	65.87	0.73	0.82	0.26	0.82
9.000	23.40	19.90	57.22	0.65	0.80	0.25	0.80
8.000	22.80	19.30	48.27	0.57	0.77	0.25	0.76
7.000	22.20	18.70	39.30	0.48	0.75	0.24	0.63
6.000	21.60	18.10	30.59	0.38	0.72	0.23	0.51
5.000	21.00	17.50	22.44	0.29	0.70	0.23	0.38
4.000	20.40	16.90	15.13	0.20	0.68	0.22	0.27
3.000	19.80	16.30	8.94	0.12	0.65	0.21	0.21
2.000	19.20	15.70	4.16	0.06	0.63	0.21	0.21
1.000	18.60	15.10	1.09	0.02	0.60	0.20	0.20
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (HEEL)

STR. RED FACTOR 0= 0.85   Vc = 2*(f'c)^.5*b*d   ACI EQU.(11-3)
ULT.SHEAR < 0*Vc   ACI 12.10.5.1

DISTANCE U BACK (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
10.00	24.00	20.50	8.39	31.12	26.45

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ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

TOE DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	0.50	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	4.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.67 in^2	MAX CRACK MOMENT	45.54

DISTANCE FROM TOE (FT)	TOE THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
2.00	24.00	19.50	8.85	0.10	0.78	0.26	0.26
1.50	24.00	19.50	5.03	0.06	0.78	0.26	0.26
1.00	24.00	19.50	2.26	0.03	0.78	0.26	0.26
0.50	24.00	19.50	0.57	0.01	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26

CHECK SHEAR (TOE)

STR. RED FACTOR 0=	0.85	Vc = 2*(f'c)^.5*b*d	ACI EQU.(11-3)
		ULT.SHEAR < 0*Vc	ACI 12.10.5.1

DISTANCE FROM TOE (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
2.00	24.00	19.50	8.66	29.60	25.16

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

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RETAINING WALL DESIGN 02/11/92

BASED ON ENGINEER MANUAL EM 1110-2-2502
VERSION WITH RESISTING SOIL CHECK

WALL SECTION PROPERTIES

TOTAL HEIGHT,VT (FT.)	17.000	HEEL DEPTH @ BACK,V8 (FT)	1.500
FOOTING DEPTH TOE,V1 (FT.)	2.000	STEM BATTER	0.0625
STEM HEIGHT,V2 (FT.)	15.000	WALL WIDTH AT TOP,H1 (FT.)	1.500
STRAIGHT WALL HT.,V3 (FT.)	15.000	WALL WIDTH AT BOT.,H2 (FT.)	1.500
SLOPED WALL HT., V4 (FT.)	0.000	WALL SLOPE,H3 (FT.)	0.000
B.O.F. TO T.O.S., V5 (FT.)	3.000	FOOTING TOE WIDTH,H4 (FT.)	2.000
SOIL DEPTH, V6 (FT.)	1.000	FOOTING HEEL WIDTH,H5 (FT.)	10.000
FOOTING DEPTH HEEL, V7(FT)	2.000	FOOTING WIDTH,HT (FT.)	13.500
		UNIT WEIGHT CONC.,(K/CUFT)	0.150
DEPTH OF RIPRAP IN CHANNEL	0.000	UNIT WEIGHT RIPRAP,(K/CUFT)	0.135

ADDITIONAL VERTICAL LOADS

LOADS ON BACKFILL		LOADS ON STRUCTURAL WEDGE ***	
HIGHWAY L.L. SURCHARGE	2.000 FT	HIGHWAY L.L. SURCHARGE	0.000 FT
LIVE LOAD SURCHARGE (vd)*	0.000 K/FT	LIVE LOAD SURCHARGE	0.000 K/FT
Vd =	0.000 K	SURCHARGE (Vs)	0.000 K
SURCHARGE LOCATION S =	-0.750 FT	DIST. TO F. WALL FACE	6.125 FT
(DRIVING WEDGE) X =	0.000 FT	SURCHARGE LOCATION X1=	1.500 FT
LOADS ON RESISTING WEDGE		FROM F. FACE OF WALL X2=	10.750 FT
LIVE LOAD SURCHARGE (vr)**	0.000 K/FT		
Vr =	0.000 K	PARAPET LOAD	
SURCHARGE LOCATION S =	0.000 FT	- HEIGHT	0.000 FT
(RESISTING WEDGE) X =	0.000 FT	- WIDTH	0.000 FT

* A CHECK IS MADE TO DETERMINE IF THE SURCHARGE ON THE BACKFILL WILL LIE WITHIN THE INFLUENCE OF THE DRIVING WEDGE.
** IT IS CONSERVATIVE TO NEGLECT SURCHARGES Vr AND Vs. IF INCLUDED ASSURE THEY WILL STAY IN PLACE FOR THE CONDITION ANALYZED.
*** THESE LOADS ARE ASSUMED TO ACT ON THE BACKFILL SIDE OF WALL ONLY.

STABILITY REQUIREMENTS

LOADING CONDITIONS CASE ———> X

% OF PASSIVE PRESSURE USED	75	SLIDING SAFETY FACTOR	1.01
MIN. BASE AREA IN COMPRESS.	60	BEARING CAP. SAFETY FACTOR	1.50

SOIL PROPERTIES (DRIVING WEDGE)

FRICTION ANGLE OF SOIL (01)	33.000 DEG.,(DRIVING WEDGE)	
FRICTION ANGLE OF SOIL (02)	33.000 DEG.,(STRUCT. WEDGE)	
SLOPE OF BACKFILL RISE/RUN	0.000	
BETA ANGLE (B1)	0.000 DEG.	
POINT AT WHICH BACKFILL SLOPE BEGINS	2.00	1=SLOPE BEGINS @ STEM
SOIL DEPTH BACK of HEEL(Hz)	17.000	2=SLOPE BEGINS@BACK OF HEEL
STR. MOBILIZATION FACTOR	1.000 (SMF)	
SOIL UNIT Wt.,MOIST (§ml)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§sl)	0.1250 K/CUFT	(ENTER §ml IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b1)	0.0932 K/CUFT	
DEPTH OF CRACK (dc)	0.000 FT.	
COHESION ON SLIP PLANE C=	0.000 KSF	
COHESION ON SLIP PLANE Cd=	0.000 KSF(DEVELOPED)	= Cd = (SMF)*C

SOIL OR DRAINAGE FILL PROPERTIES (FOUNDATION MATERIAL)

FRICTION ANGLE OF SOIL (0f)	35.000 DEG.	(USED FOR BEARING CAPACITY)
FRICTION ANGLE FOR SLIDING	30.000 DEG.	(USED FOR SLIDING ANALYSIS)

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ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

FOUNDATION MATERIAL	2.000 <————————	1 - SOIL FOUNDATION
SOIL UNIT Wt.,MOIST (§m2)	0.130 K/CUFT	2 - ROCK FOUNDATION
SOIL UNIT Wt.,SATUR. (§s2)	0.137 K/CUFT	{ENTER §m2 IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b2)	0.0745 K/CUFT	
COHESION OF FOUNDATION Cfs=	0.000 KSF	(USED FOR SLIDING ANALYSIS)
LENGTH OF COHESION, Cl=	13.500 FT	

UNDERLYING ROCK PROPERTIES

ROCK UNIT Wt., (§r2)	0.1600 K/CUFT	
COHESION OF FOUNDATION Cfr=	7.200 KSF	(USED FOR BEARING CAPACITY)

SOIL PROPERTIES (RESISTING WEDGE)

FRICTION ANGLE OF SOIL (03)	33.000 DEG.	
SLOPE OF OVERLAY,RISE/RUN	-0.300	
BETA ANGLE (B3)	-16.699 DEG.	
SOIL DEPTH TOE SIDE	3.000 FT.	
SOIL UNIT Wt.,MOIST (§m3)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§s3)	0.1250 K/CUFT	{ENTER §m3 IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b3)	0.0319 K/CUFT	
COHESION ON SLIP PLANE Cr=	0.000 KSF	

WATER PRESSURE PROPERTIES

SATURATION HT. BACKSIDE(h1)	13.00	DIFFERENTIAL HEAD(<h) =	13.00
SATURATION HT.FRONT (h2)	0.00	WATER Ht. ABOVE	
HEIGHT OF MOIST SOIL (hm)	4.00	WATER Ht. IN STREAM(hw)	0.00
WATER UNIT WEIGHT (§w)	0.0625 K/CUFT		

STRUCTURAL CONCRETE PROPERTIES

CONC. STRENGTH (KSI) f'c=	4.00		COVER TO C.G. REINF.(IN)	
REINF.STR.(KSI)fy=	60.00		STEM =	3.50
LOAD FACTOR	1.66		HEEL =	3.50
STR. REDUCT FACTOR	0.90	(MOMENT)	TOE =	4.50
STR. REDUCT FACTOR	0.85	(SHEAR)	p max =	0.00713
WALL INCREMENT (FT)	1.00		p min =	0.00333

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 4 1992
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SUMMATION OF MOMENTS ABOUT THE TOE

AREA	VERT.	HORIZ.	WIDTH (FT)	UNIT WT. (K/CU.FT)	P VERT. (K/FT)	D (ARM)	M (FT-kips)
1	15.000	1.500	1.000	0.150	3.375	2.750	9.28
2	0.000	0.000	1.000	0.150	0.000	3.500	0.00
3	2.000	3.500	1.000	0.150	1.050	1.750	1.84
4	1.750	10.000	1.000	0.150	2.625	8.262	21.69
5	1.000	2.000	1.000	0.120	0.240	1.000	0.24
5A	0.000	2.000	1.000	0.125	0.000	1.000	0.00
5B	0.000	2.000	1.000	0.135	0.000	1.000	0.00
5C	0.000	2.000	1.000	0.063	0.000	1.000	0.00
6	4.000	0.000	1.000	0.120	0.000	3.500	0.00
6A	11.000	0.000	1.000	0.125	0.000	3.500	0.00
7	0.000	0.000	1.000	0.120	0.000	0.000	0.00
7A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
8	4.000	10.000	1.000	0.120	4.800	8.500	40.80
8A	11.000	10.000	1.000	0.125	13.750	8.500	116.88
9	0.500	5.000	1.000	0.125	0.313	10.167	3.18
10	0.000	5.000	1.000	0.120	0.000	10.167	0.00
PARAPET	0.000	0.000	1.000	0.150	0.000	2.750	0.00
DL TOTAL					26.153	7.414	193.90

	P HOR.	P VERT.	D (ARM)	M (FT-kips)
HORIZONTAL WEDGE LOADS:				
L.E.P. SOIL (DRIVING)	-4.443		5.87	-26.07
VERTICAL COMPONENT		0.00	0.00	0.00
LATERAL WATER (DRIVING)	-2.69		4.33	-11.66
SURCHARGE (DRIVING)	0.00		0.00	0.00
L.E.P. SOIL + SURCHARGE (RESISTING)	0.25		1.00	0.25
VERTICAL COMPONENT (NOT COMPUTED)		0.00	0.00	0.00
LATERAL WATER (RESISTING)	0.000		0.00	0.00
UPLIFT		-2.79	9.00	-25.15
SUBTOTAL ———>	-6.89	23.36	5.62	131.3
ADDITIONAL LOADS				
HIGHWAY L.L. SURCHARGE - FM BACKFILL	-1.20		8.50	-10.22
- VERT. ON STRUCTURAL WEDGE		0.00	8.500	0.00
SURCHARGE (STRUCTURAL WEDGE - Vs)		0.00	8.13	0.00
TOTAL ———>	-8.09	23.36	5.18	121.04

TOTAL WEIGHT OF STRUCTURAL WEDGE = 23.36 kips

OVERTURNING STABILITY ANALYSIS

Xr= SUM MOMENT ABOUT TOE/SUM OF VERTICAL FORCES
SUM MOM= 121.0 F-kips
Pvert = 23.36 kips $\overline{X}$ = 5.18 FT.

ECCENTRICITY e= HT/2-$\overline{X}$ = 1.57 < 2.25 = HT/6

% BASE IN COMP.= 3*X/HT =" 100.0 %

CRITERIA SATISFIED

SLIDING STABILITY ANALYSIS

N' = Vsum = 23.36 kips T = Hsum = 8.09 kips
0 = 30.00 L = % BASE IN COMPRESSION * HT = 13.50
C = 0.00 FS = 1.01

N'*TANO/FS (NO COHESION INCLUDED) = 13.35 kips

RESISTING SOIL FORCE REQUIRED = 0.00 kips

ALLOW. PASSIVE SOIL + SURCHARGE = 0.79 kips
AT REST SOIL + SURCHARGE = 0.25 kips

FS = 1.67 -> SLIDING CRITERIA IS SATISFIED

CHECK BEARING CAPACITY

BEARING CAPACITY = Q EQU. 5-2
Q= $\overline{B}$[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB(§m-f)Nr)/2]

ECCEN. OF LOAD e= 1.57

EFFECTIVE WIDTH OF BASE $\overline{B}$= HT-2e = 10.36

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502
Nq = 33.30
Nc = 46.12
Nr = 37.15

EMBEDMENT FACTORS
Ecd =1+0.2(V5/$\overline{B}$)TAN(45+0/2) = 1.107 EQU.5-4a
Eqd=Erd = = 1.000 EQU.5-4b IF(0 = 0)
Eqd=Erd =1+0.1(V5/$\overline{B}$)TAN(45+0/2) = EQU.5-4c IF(0 >10)
Eqd=Erd = = 1.053 FOR (0<0<=10)
INTERPOLATE BETWEEN EQU. 5-4b AND 4c

INCLINATION FACTORS
§o = ARCTAN[(SUM H)/SUM V] = 19.11 DEG.
Eqi=Eci =(1-§o/90)^2 = 0.620 EQU.5-5a
Eri =IF §o > FRIC. ANGLE(0) THEN Eri = 0, ELSE,
Eri =(1-§o/0)^2 = 0.206 EQU.5-5b

BASE TILT FACTORS (A2 IN RADIANS)
Eqt=Ert =(1-a2*TANO)^2 = 1.000 EQU.5-6a
Ect =1-(2*a2/PI+2) EQU.5-6b (IF 0 =0)
Ect =Eqt-[(1-Eqt)/(NcTANO)] EQU.5-6c (IF 0 >0)
Ect = 1.000

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

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GROUND SLOPE FACTORS

```
        Erg=Eqg =[1-TAN(-B3)]^2 =                0.490 EQU.5-7a
            Ecg =1-[2*(-B3)/(PI+2)]  (B3 IN RAD.)      EQU.5-7b (IF 0 =0)
            Ecg =Eqg-[(1-Eqg)/Nc*TAN0]                  EQU.5-7d (IF 0 >0)
            Ecg =                                0.483
```

EFFECTIVE OVERBURDEN PRESSURE

```
                 qo =(§3*V5+RIPRAP)*COS/B3/ =    0.345 EQU.5-8a

                BEARING CAPACITY = 1199.80 kips       EQU. 5-2
                                   ---------
                 F.O.S. =Q/SUM V=     51.4            EQU. 5-1
                                   ---------
                        BEARING CAPACITY IS SATISFIED
```

BASE PRESSURES DISTRIBUTION (FOOTING)

```
   p1= P/HT*(1+6*e/HT) =      IF e IS IN MIDDLE 1/3 OF FOOTING
   p1 =2*P/(3*(HT/2-e)) =     IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING

   p2= P/HT*(1-6*e/HT) =      IF e IS IN MIDDLE 1/3 OF FOOTING
   p2 = 0                     IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING
                                DISTANCE TO p2   =      13.50 FT

          p1 =   2.9359 KSF          p2 =   0.5245 KSF
```

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

STEM DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI) f'c=	4.00	REINF.STR.(KSI)fy=	60.00
COVER TO C.G. REINF.(IN)	3.50	LOAD FACTOR	1.66
WALL INCREMENT (FT)	1.00	STR. REDUCT FACTOR	0.90
As max based on p max =	1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE ABOVE FT TOP (FT)	WALL THICK. (IN)	d (IN)	ULT. MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
0.00	18.00	14.50	55.04	0.88	0.58	0.19	0.88
1.00	18.00	14.50	44.99	0.72	0.58	0.19	0.72
2.00	18.00	14.50	36.25	0.57	0.58	0.19	0.58
3.00	18.00	14.50	28.76	0.45	0.58	0.19	0.58
4.00	18.00	14.50	22.40	0.35	0.58	0.19	0.47
5.00	18.00	14.50	17.09	0.27	0.58	0.19	0.35
6.00	18.00	14.50	12.72	0.20	0.58	0.19	0.26
7.00	18.00	14.50	9.19	0.14	0.58	0.19	0.19
8.00	18.00	14.50	6.41	0.10	0.58	0.19	0.19
9.00	18.00	14.50	4.28	0.07	0.58	0.19	0.19
10.00	18.00	14.50	2.70	0.04	0.58	0.19	0.19
11.00	18.00	14.50	1.57	0.02	0.58	0.19	0.19
12.00	18.00	14.50	0.79	0.01	0.58	0.19	0.19
13.00	18.00	14.50	0.31	0.00	0.58	0.19	0.19
14.00	18.00	14.50	0.07	0.00	0.58	0.19	0.19
15.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
16.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
17.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
18.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
19.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
20.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
21.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
22.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (STEM)

STR. RED FACTOR 0= 0.85

Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 2/3*0*Vc ACI 12.10.5.1
AT CUT OF POINT

DISTANCE ABOVE FT BOTT (FT)	WALL THICK. (IN)	D (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
0.00	18.00	14.50	10.73	22.01	18.71

MAR 4 1992
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ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

HEEL DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	1.00	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	3.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.75 in^2	MAX CRACK MOMENT	45.54

DISTANCE FROM HEEL BACK (FT)	HEEL THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
10.000	24.00	20.50	59.35	0.66	0.82	0.26	0.82
9.000	23.40	19.90	51.36	0.59	0.80	0.25	0.78
8.000	22.80	19.30	43.18	0.51	0.77	0.25	0.68
7.000	22.20	18.70	35.05	0.42	0.75	0.24	0.56
6.000	21.60	18.10	27.21	0.34	0.72	0.23	0.45
5.000	21.00	17.50	19.91	0.26	0.70	0.23	0.34
4.000	20.40	16.90	13.39	0.18	0.68	0.22	0.24
3.000	19.80	16.30	7.90	0.11	0.65	0.21	0.21
2.000	19.20	15.70	3.67	0.05	0.63	0.21	0.21
1.000	18.60	15.10	0.96	0.01	0.60	0.20	0.20
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (HEEL)

STR. RED FACTOR 0= 0.85 Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 0*Vc ACI 12.10.5.1

DISTANCE U BACK (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
10.00	24.00	20.50	7.81	31.12	26.45

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

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TOE DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	0.50	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	4.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.67 in^2	MAX CRACK MOMENT	45.54

DISTANCE FROM TOE (FT)	TOE THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
2.00	24.00	19.50	8.42	0.10	0.78	0.26	0.26
1.50	24.00	19.50	4.78	0.05	0.78	0.26	0.26
1.00	24.00	19.50	2.15	0.02	0.78	0.26	0.26
0.50	24.00	19.50	0.54	0.01	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26
0.00	24.00	19.50	0.00	0.00	0.78	0.26	0.26

CHECK SHEAR (TOE)

STR. RED FACTOR 0= 0.85 Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 0*Vc ACI 12.10.5.1

DISTANCE FROM TOE (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
2.00	24.00	19.50	8.26	29.60	25.16

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT , Final @ 24' of the wall

RETAINING WALL DESIGN 02/12/92

MAR 5 1992
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BASED ON ENGINEER MANUAL EM 1110-2-2502
VERSION WITH RESISTING SOIL CHECK

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                         WALL SECTION PROPERTIES
TOTAL HEIGHT,VT (FT.)         12.600 HEEL DEPTH @ BACK,V8 (FT)      1.500
FOOTING DEPTH TOE,V1 (FT.)     1.500 STEM BATTER                    0.0625
STEM HEIGHT,V2 (FT.)          11.100 WALL WIDTH AT TOP,H1 (FT.)     1.500
STRAIGHT WALL HT.,V3 (FT.)    11.100 WALL WIDTH AT BOT.,H2 (FT.)    1.500
SLOPED WALL HT., V4 (FT.)      0.000 WALL SLOPE,H3 (FT.)            0.000
B.O.F. TO T.O.S., V5 (FT.)     2.000 FOOTING TOE WIDTH,H4 (FT.)     2.000
SOIL DEPTH, V6 (FT.)           0.500 FOOTING HEEL WIDTH,H5 (FT.)    7.500
FOOTING DEPTH HEEL, V7(FT)     1.500 FOOTING WIDTH,HT (FT.)        11.000
                                     UNIT WEIGHT CONC.,(K/CUFT)     0.150
DEPTH OF RIPRAP IN CHANNEL     0.000 UNIT WEIGHT RIPRAP,(K/CUFT)    0.135
-----------------------------------------------------------------------------
                       ADDITIONAL VERTICAL LOADS
LOADS ON BACKFILL                        LOADS ON STRUCTURAL WEDGE ***
 HIGHWAY L.L. SURCHARGE        0.700 FT    HIGHWAY L.L. SURCHARGE    0.000 FT
 LIVE LOAD SURCHARGE (vd)*     0.000 K/FT LIVE LOAD SURCHARGE        0.000 K/FT
 Vd =                          0.000 K       SURCHARGE (Vs)          0.000 K
 SURCHARGE LOCATION     S =    1.750 FT    DIST. TO F. WALL FACE     5.250 FT
  (DRIVING WEDGE)       X =    0.000 FT SURCHARGE LOCATION    X1=    1.500 FT
LOADS ON RESISTING WEDGE                FROM F. FACE OF WALL X2=     9.000 FT
 LIVE LOAD SURCHARGE (vr)**    0.000 K/FT
 Vr =                          0.000 K       PARAPET LOAD
 SURCHARGE LOCATION     S =    0.000 FT        -  HEIGHT             0.000 FT
  (RESISTING WEDGE)     X =    0.000 FT        -  WIDTH              0.000 FT
*  A CHECK IS MADE TO DETERMINE IF THE SURCHARGE ON THE BACKFILL WILL
   LIE WITHIN THE INFLUENCE OF THE DRIVING WEDGE.
** IT IS CONSERVATIVE TO NEGLECT SURCHARGES Vr AND Vs.  IF INCLUDED
   ASSURE THEY WILL STAY IN PLACE FOR THE CONDITION ANALYZED.
*** THESE LOADS ARE ASSUMED TO ACT ON THE BACKFILL SIDE OF WALL ONLY.
-----------------------------------------------------------------------------
                        STABILITY  REQUIREMENTS
LOADING CONDITIONS CASE ------->    R1
% OF PASSIVE PRESSURE USED         50 SLIDING SAFETY FACTOR           1.50
MIN. BASE AREA IN COMPRESS.       100 BEARING CAP. SAFETY FACTOR      2.50
-----------------------------------------------------------------------------
                         SOIL PROPERTIES (DRIVING WEDGE)
FRICTION ANGLE OF SOIL (01)  33.000 DEG.,(DRIVING WEDGE)
FRICTION ANGLE OF SOIL (02)  33.000 DEG.,(STRUCT. WEDGE)
SLOPE OF BACKFILL RISE/RUN    0.000
BETA ANGLE (B1)               0.000 DEG.
POINT AT WHICH BACKFILL SLOPE BEGINS    2.00 1-SLOPE BEGINS @ STEM
SOIL DEPTH BACK of HEEL(Hz)  12.600          2-SLOPE BEGINS@BACK OF HEEL
STR. MOBILIZATION FACTOR      0.667 (SMF)
SOIL UNIT Wt.,MOIST (§m1)     0.1200 K/CUFT
SOIL UNIT Wt.,SATUR. (§s1)    0.1250 K/CUFT   (ENTER §m1 IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b1)   0.0700 K/CUFT
DEPTH OF CRACK (dc)           0.000 FT.
COHESION ON SLIP PLANE C=     0.000 KSF
COHESION ON SLIP PLANE Cd=    0.000 KSF(DEVELOPED)  = Cd = (SMF)*C

-----------------------------------------------------------------------------
           SOIL OR DRAINAGE FILL PROPERTIES (FOUNDATION MATERIAL)
FRICTION ANGLE OF SOIL (0f)  31.000 DEG. (USED FOR BEARING CAPACITY)
FRICTION ANGLE FOR SLIDING   28.000 DEG. (USED FOR SLIDING ANALYSIS)
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ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992

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FOUNDATION MATERIAL	1.000 <————	1 - SOIL FOUNDATION
SOIL UNIT Wt.,MOIST (§m2)	0.115 K/CUFT	2 - ROCK FOUNDATION
SOIL UNIT Wt.,SATUR. (§s2)	0.122 K/CUFT	(ENTER §m2 IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b2)	0.0595 K/CUFT	
COHESION OF FOUNDATION Cfs-	0.000 KSF	(USED FOR SLIDING ANALYSIS)
LENGTH OF COHESION, Cl-	11.000 FT	

UNDERLYING ROCK PROPERTIES

ROCK UNIT Wt., (§r2)	0.0000 K/CUFT	
COHESION OF FOUNDATION Cfr-	0.000 KSF	(USED FOR BEARING CAPACITY)

SOIL PROPERTIES (RESISTING WEDGE)

FRICTION ANGLE OF SOIL (03)	33.000 DEG.	
SLOPE OF OVERLAY,RISE/RUN	0.000	
BETA ANGLE (B3)	0.000 DEG.	
SOIL DEPTH TOE SIDE	2.000 FT.	
SOIL UNIT Wt.,MOIST (§m3)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§s3)	0.1250 K/CUFT	(ENTER §m3 IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b3)	0.0551 K/CUFT	
COHESION ON SLIP PLANE Cr-	0.000 KSF	

WATER PRESSURE PROPERTIES

SATURATION HT. BACKSIDE(h1)	1.50	DIFFERENTIAL HEAD(<h) -	1.50
SATURATION HT.FRONT (h2)	0.00	WATER Ht. ABOVE	
HEIGHT OF MOIST SOIL (hm)	11.10	WATER Ht. IN STREAM(hw)	0.00
WATER UNIT WEIGHT (§w)	0.0625 K/CUFT		

STRUCTURAL CONCRETE PROPERTIES

CONC. STRENGTH (KSI) f'c-	4.00		COVER TO C.G. REINF.(IN)	
REINF.STR.(KSI)fy-	60.00		STEM -	3.50
LOAD FACTOR	2.21		HEEL -	3.50
STR. REDUCT FACTOR	0.90	(MOMENT)	TOE -	4.50
STR. REDUCT FACTOR	0.85	(SHEAR)	p max -	0.00713
WALL INCREMENT (FT)	1.00		p min -	0.00333

SUMMATION OF MOMENTS ABOUT THE TOE

AREA	VERT.	HORIZ.	WIDTH (FT)	UNIT WT. (K/CU.FT)	P VERT. (K/FT)	D (ARM)	M (FT-kips)
1	11.100	1.500	1.000	0.150	2.498	2.750	6.87
2	0.000	0.000	1.000	0.150	0.000	3.500	0.00
3	1.500	3.500	1.000	0.150	0.788	1.750	1.38
4	1.500	7.500	1.000	0.150	1.688	7.250	12.23
5	0.500	2.000	1.000	0.120	0.120	1.000	0.12
5A	0.000	2.000	1.000	0.125	0.000	1.000	0.00
5B	0.000	2.000	1.000	0.135	0.000	1.000	0.00
5C	0.000	2.000	1.000	0.063	0.000	1.000	0.00
6	11.100	0.000	1.000	0.120	0.000	3.500	0.00
6A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
7	0.000	0.000	1.000	0.120	0.000	0.000	0.00
7A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
8	11.100	7.500	1.000	0.120	9.990	7.250	72.43
8A	0.000	7.500	1.000	0.125	0.000	7.250	0.00
9	0.000	3.750	1.000	0.125	0.000	8.500	0.00
10	0.000	3.750	1.000	0.120	0.000	8.500	0.00
PARAPET	0.000	0.000	1.000	0.150	0.000	2.750	0.00
DL TOTAL					15.083	6.168	93.03

	P HOR.	P VERT.	D	M
HORIZONTAL WEDGE LOADS:				
L.E.P. SOIL (DRIVING)	-4.084		4.22	-17.24
VERTICAL COMPONENT		0.00	0.00	0.00
LATERAL WATER (DRIVING)	-0.06		0.50	-0.03
SURCHARGE (DRIVING)	0.00		0.00	0.00
L.E.P. SOIL + SURCHARGE (RESISTING)	0.11		0.67	0.07
VERTICAL COMPONENT (NOT COMPUTED)		0.00	0.00	0.00
LATERAL WATER (RESISTING)	0.000		0.00	0.00
UPLIFT		-0.45	7.33	-3.33
SUBTOTAL ———>	-4.04	14.63	4.96	72.5
ADDITIONAL LOADS				
HIGHWAY L.L. SURCHARGE - FM BACKFILL	-0.46		6.30	-2.88
- VERT. ON STRUCTURAL WEDGE		0.00	7.250	0.00
SURCHARGE (STRUCTURAL WEDGE - Vs)		0.00	7.25	0.00
TOTAL ———>	-4.49	14.63	4.76	69.62

TOTAL WEIGHT OF STRUCTURAL WEDGE = 14.63 kips

CWB
126

OVERTURNING STABILITY ANALYSIS

Xr= SUM MOMENT ABOUT TOE/SUM OF VERTICAL FORCES
SUM MOM= 69.6 F-kips
Pvert = 14.63 kips $\bar{X}$ = 4.76 FT.

ECCENTRICITY e= HT/2-$\bar{X}$ = 0.74 < 1.83 = HT/6

% BASE IN COMP.= 3*X/HT =" 100.0 %

CRITERIA SATISFIED

SLIDING STABILITY ANALYSIS

N' = Vsum =	14.63 kips	T = Hsum =	4.49 kips
0 = 28.00		L = % BASE IN COMPRESSION * HT =	11.00
C = 0.00		FS =	1.50

N'*TANO/FS (NO COHESION INCLUDED) = 5.19 kips

RESISTING SOIL FORCE REQUIRED = 0.00 kips

ALLOW. PASSIVE SOIL + SURCHARGE = 0.28 kips
AT REST SOIL + SURCHARGE = 0.11 kips

FS = 1.73 -> SLIDING CRITERIA IS SATISFIED

CHECK BEARING CAPACITY

BEARING CAPACITY = Q EQU. 5-2
Q= $\bar{B}$[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB(§m-f)Nr)/2]

ECCEN. OF LOAD e= 0.74

EFFECTIVE WIDTH OF BASE $\bar{B}$= HT-2e = 9.52

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502
Nq = 20.63
Nc = 32.67
Nr = 18.56

EMBEDMENT FACTORS
Ecd =1+0.2(V5/$\bar{B}$)TAN(45+0/2) = 1.077 EQU.5-4a
Eqd=Erd = = 1.000 EQU.5-4b IF(0 = 0)
Eqd=Erd =1+0.1(V5/$\bar{B}$)TAN(45+0/2) = EQU.5-4c IF(0 >10)
Eqd=Erd = = 1.039 FOR (0<0<=10)
INTERPOLATE BETWEEN EQU. 5-4b AND 4c

INCLINATION FACTORS
§o = ARCTAN[(SUM H)/SUM V] = 17.08 DEG.
Eqi=Eci =(1-§o/90)^2 = 0.657 EQU.5-5a
Eri =IF §o > FRIC. ANGLE(0) THEN Eri = 0, ELSE,
Eri =(1-§o/0)^2 = 0.202 EQU.5-5b

BASE TILT FACTORS (A2 IN RADIANS)
Eqt=Ert =(1-a2*TANO)^2 = 1.000 EQU.5-6a
Ect =1-(2*a2/PI+2) EQU.5-6b (IF 0 =0)
Ect =Eqt-[(1-Eqt)/(NcTANO)] EQU.5-6c (IF 0 >0)
Ect = 1.000

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992
CWB
136'

GROUND SLOPE FACTORS

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        Erg=Eqg =[1-TAN(-B3)]^2 =                1.000 EQU.5-7a
            Ecg =1-[2*(-B3)/(PI+2)]  (B3 IN RAD.)      EQU.5-7b (IF 0 =0)
            Ecg =Eqg-[(1-Eqg)/Nc*TANO]                 EQU.5-7d (IF 0 >0)
            Ecg =                                1.000
```

EFFECTIVE OVERBURDEN PRESSURE

```
            qo =(§3*V5+RIPRAP)*COS/B3/ =         0.240 EQU.5-8a

            BEARING CAPACITY =    42.62 kips     EQU. 5-2
                                  ---------
              F.O.S. =Q/SUM V=     2.9           EQU. 5-1
                                  ---------
                         BEARING CAPACITY IS SATISFIED
```

BASE PRESSURES DISTRIBUTION (FOOTING)

```
    p1= P/HT*(1+6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
    p1 =2*P/(3*(HT/2-e)) =      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING

    p2= P/HT*(1-6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
    p2 = 0                      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING
                                  DISTANCE TO p2   =      11.00 FT

            p1 =   1.8671 KSF         p2 =   0.7926 KSF
```

CW
11

STEM DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI) f'c=	4.00	REINF.STR.(KSI)fy=	60.00
COVER TO C.G. REINF.(IN)	3.50	LOAD FACTOR	2.21
WALL INCREMENT (FT)	1.00	STR. REDUCT FACTOR	0.90
As max based on p max =	1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE ABOVE FT TOP (FT)	WALL THICK. (IN)	d (IN)	ULT. MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
0.00	18.00	14.50	31.00	0.49	0.58	0.19	0.58
1.00	18.00	14.50	23.73	0.37	0.58	0.19	0.49
2.00	18.00	14.50	17.68	0.27	0.58	0.19	0.37
3.00	18.00	14.50	12.76	0.20	0.58	0.19	0.26
4.00	18.00	14.50	8.84	0.14	0.58	0.19	0.19
5.00	18.00	14.50	5.82	0.09	0.58	0.19	0.19
6.00	18.00	14.50	3.57	0.05	0.58	0.19	0.19
7.00	18.00	14.50	1.99	0.03	0.58	0.19	0.19
8.00	18.00	14.50	0.95	0.01	0.58	0.19	0.19
9.00	18.00	14.50	0.35	0.01	0.58	0.19	0.19
10.00	18.00	14.50	0.07	0.00	0.58	0.19	0.19
11.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
12.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
13.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
14.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
15.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
16.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
17.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
18.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
19.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
20.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
21.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
22.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (STEM)

STR. RED FACTOR 0= 0.85

Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 2/3*0*Vc ACI 12.10.5.1
AT CUT OF POINT

DISTANCE ABOVE FT BOTT (FT)	WALL THICK. (IN)	D (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
0.00	18.00	14.50	7.92	22.01	18.71

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT MAR 5 1992

CWB
DH

HEEL DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	1.00	LOAD FACTOR	2.21
COVER TO C.G. REINF.(IN)	3.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE FROM HEEL BACK (FT)	HEEL THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
7.500	18.00	14.50	28.37	0.44	0.58	0.19	0.58
6.500	18.00	14.50	22.71	0.35	0.58	0.19	0.47
5.500	18.00	14.50	17.27	0.27	0.58	0.19	0.36
4.500	18.00	14.50	12.23	0.19	0.58	0.19	0.25
3.500	18.00	14.50	7.81	0.12	0.58	0.19	0.19
2.500	18.00	14.50	4.19	0.06	0.58	0.19	0.19
1.500	18.00	14.50	1.58	0.02	0.58	0.19	0.19
0.500	18.00	14.50	0.18	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (HEEL)

STR. RED FACTOR 0=	0.85	Vc = 2*(f'c)^.5*b*d	ACI EQU.(11-3)
		ULT.SHEAR < 0*Vc	ACI 12.10.5.1

DISTANCE U BACK (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
7.50	18.00	14.50	5.70	22.01	18.71

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 19
CWl
D

TOE DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	0.50	LOAD FACTOR	2.21
COVER TO C.G. REINF.(IN)	4.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.15 in^2	MAX CRACK MOMENT	25.61

DISTANCE FROM TOE (FT)	TOE THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
2.00	18.00	13.50	6.99	0.12	0.54	0.19	0.19
1.50	18.00	13.50	3.97	0.07	0.54	0.19	0.19
1.00	18.00	13.50	1.78	0.03	0.54	0.19	0.19
0.50	18.00	13.50	0.45	0.01	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19

CHECK SHEAR (TOE)

STR. RED FACTOR 0=	0.85	Vc = 2*(f'c)^.5*b*d	ACI EQU.(11-3)
		ULT.SHEAR < 0*Vc	ACI 12.10.5.1

DISTANCE FROM TOE (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
2.00	18.00	13.50	6.86	20.49	17.42

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992

CWB
06J

RETAINING WALL DESIGN 02/12/92

BASED ON ENGINEER MANUAL EM 1110-2-2502
VERSION WITH RESISTING SOIL CHECK

WALL SECTION PROPERTIES

TOTAL HEIGHT,VT (FT.)	12.600	HEEL DEPTH @ BACK,V8 (FT)	1.500
FOOTING DEPTH TOE,V1 (FT.)	1.500	STEM BATTER	0.0625
STEM HEIGHT,V2 (FT.)	11.100	WALL WIDTH AT TOP,H1 (FT.)	1.500
STRAIGHT WALL HT.,V3 (FT.)	11.100	WALL WIDTH AT BOT.,H2 (FT.)	1.500
SLOPED WALL HT., V4 (FT.)	0.000	WALL SLOPE,H3 (FT.)	0.000
B.O.F. TO T.O.S., V5 (FT.)	2.000	FOOTING TOE WIDTH,H4 (FT.)	2.000
SOIL DEPTH, V6 (FT.)	0.500	FOOTING HEEL WIDTH,H5 (FT.)	7.500
FOOTING DEPTH HEEL, V7(FT)	1.500	FOOTING WIDTH,HT (FT.)	11.000
		UNIT WEIGHT CONC.,(K/CUFT)	0.150
DEPTH OF RIPRAP IN CHANNEL	0.000	UNIT WEIGHT RIPRAP,(K/CUFT)	0.135

ADDITIONAL VERTICAL LOADS

LOADS ON BACKFILL		LOADS ON STRUCTURAL WEDGE ***	
HIGHWAY L.L. SURCHARGE	2.000 FT	HIGHWAY L.L. SURCHARGE	0.000 FT
LIVE LOAD SURCHARGE (vd)*	0.000 K/FT	LIVE LOAD SURCHARGE	0.000 K/FT
Vd =	0.000 K	SURCHARGE (Vs)	0.000 K
SURCHARGE LOCATION S =	1.750 FT	DIST. TO F. WALL FACE	5.250 FT
(DRIVING WEDGE) X =	0.000 FT	SURCHARGE LOCATION X1=	1.500 FT
LOADS ON RESISTING WEDGE		FROM F. FACE OF WALL X2=	9.000 FT
LIVE LOAD SURCHARGE (vr)**	0.000 K/FT		
Vr =	0.000 K	PARAPET LOAD	
SURCHARGE LOCATION S =	0.000 FT	- HEIGHT	0.000 FT
(RESISTING WEDGE) X =	0.000 FT	- WIDTH	0.000 FT

* A CHECK IS MADE TO DETERMINE IF THE SURCHARGE ON THE BACKFILL WILL LIE WITHIN THE INFLUENCE OF THE DRIVING WEDGE.

** IT IS CONSERVATIVE TO NEGLECT SURCHARGES Vr AND Vs. IF INCLUDED ASSURE THEY WILL STAY IN PLACE FOR THE CONDITION ANALYZED.

*** THESE LOADS ARE ASSUMED TO ACT ON THE BACKFILL SIDE OF WALL ONLY.

STABILITY REQUIREMENTS

LOADING CONDITIONS CASE ———>	R2		
% OF PASSIVE PRESSURE USED	50	SLIDING SAFETY FACTOR	1.33
MIN. BASE AREA IN COMPRESS.	75	BEARING CAP. SAFETY FACTOR	2.00

SOIL PROPERTIES (DRIVING WEDGE)

FRICTION ANGLE OF SOIL (01)	33.000	DEG.,(DRIVING WEDGE)
FRICTION ANGLE OF SOIL (02)	33.000	DEG.,(STRUCT. WEDGE)
SLOPE OF BACKFILL RISE/RUN	0.000	
BETA ANGLE (B1)	0.000	DEG.
POINT AT WHICH BACKFILL SLOPE BEGINS	2.00	1=SLOPE BEGINS @ STEM
SOIL DEPTH BACK of HEEL(Hz)	12.600	2=SLOPE BEGINS@BACK OF HEEL
STR. MOBILIZATION FACTOR	0.750	(SMF)
SOIL UNIT Wt.,MOIST (§ml)	0.1200	K/CUFT
SOIL UNIT Wt.,SATUR. (§s1)	0.1250	K/CUFT (ENTER §ml IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b1)	0.0820	K/CUFT
DEPTH OF CRACK (dc)	0.000	FT.
COHESION ON SLIP PLANE C=	0.000	KSF
COHESION ON SLIP PLANE Cd=	0.000	KSF(DEVELOPED) = Cd = (SMF)*C

SOIL OR DRAINAGE FILL PROPERTIES (FOUNDATION MATERIAL)

FRICTION ANGLE OF SOIL (0f)	31.000	DEG. (USED FOR BEARING CAPACITY)
FRICTION ANGLE FOR SLIDING	28.000	DEG. (USED FOR SLIDING ANALYSIS)

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992

Cv

FOUNDATION MATERIAL	1.000 <————	1 - SOIL FOUNDATION
SOIL UNIT Wt.,MOIST (§m2)	0.115 K/CUFT	2 - ROCK FOUNDATION
SOIL UNIT Wt.,SATUR. (§s2)	0.122 K/CUFT	(ENTER §m2 IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b2)	0.0595 K/CUFT	
COHESION OF FOUNDATION Cfs-	0.000 KSF	(USED FOR SLIDING ANALYSIS)
LENGTH OF COHESION, C1-	11.000 FT	

UNDERLYING ROCK PROPERTIES

ROCK UNIT Wt., (§r2)	0.0000 K/CUFT	
COHESION OF FOUNDATION Cfr-	0.000 KSF	(USED FOR BEARING CAPACITY)

SOIL PROPERTIES (RESISTING WEDGE)

FRICTION ANGLE OF SOIL (03)	33.000 DEG.	
SLOPE OF OVERLAY,RISE/RUN	0.000	
BETA ANGLE (B3)	0.000 DEG.	
SOIL DEPTH TOE SIDE	2.000 FT.	
SOIL UNIT Wt.,MOIST (§m3)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§s3)	0.1250 K/CUFT	(ENTER §m3 IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b3)	0.0431 K/CUFT	
COHESION ON SLIP PLANE Cr-	0.000 KSF	

WATER PRESSURE PROPERTIES

SATURATION HT. BACKSIDE(h1)	5.00	DIFFERENTIAL HEAD(<h) -	5.00
SATURATION HT.FRONT (h2)	0.00	WATER Ht. ABOVE	
HEIGHT OF MOIST SOIL (hm)	7.60	WATER Ht. IN STREAM(hw)	0.00
WATER UNIT WEIGHT (§w)	0.0625 K/CUFT		

STRUCTURAL CONCRETE PROPERTIES

CONC. STRENGTH (KSI) f'c-	4.00		COVER TO C.G. REINF.(IN)	
REINF.STR.(KSI)fy-	60.00		STEM -	3.50
LOAD FACTOR	1.66		HEEL -	3.50
STR. REDUCT FACTOR	0.90	(MOMENT)	TOE -	4.50
STR. REDUCT FACTOR	0.85	(SHEAR)	p max -	0.00713
WALL INCREMENT (FT)	1.00		p min -	0.00333

SUMMATION OF MOMENTS ABOUT THE TOE

AREA	VERT.	HORIZ.	WIDTH (FT)	UNIT WT. (K/CU.FT)	P VERT. (K/FT)	D (ARM)	M (FT-kips)
1	11.100	1.500	1.000	0.150	2.498	2.750	6.87
2	0.000	0.000	1.000	0.150	0.000	3.500	0.00
3	1.500	3.500	1.000	0.150	0.788	1.750	1.38
4	1.500	7.500	1.000	0.150	1.688	7.250	12.23
5	0.500	2.000	1.000	0.120	0.120	1.000	0.12
5A	0.000	2.000	1.000	0.125	0.000	1.000	0.00
5B	0.000	2.000	1.000	0.135	0.000	1.000	0.00
5C	0.000	2.000	1.000	0.063	0.000	1.000	0.00
6	7.600	0.000	1.000	0.120	0.000	3.500	0.00
6A	3.500	0.000	1.000	0.125	0.000	3.500	0.00
7	0.000	0.000	1.000	0.120	0.000	0.000	0.00
7A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
8	7.600	7.500	1.000	0.120	6.840	7.250	49.59
8A	3.500	7.500	1.000	0.125	3.281	7.250	23.79
9	0.000	3.750	1.000	0.125	0.000	8.500	0.00
10	0.000	3.750	1.000	0.120	0.000	8.500	0.00
PARAPET	0.000	0.000	1.000	0.150	0.000	2.750	0.00
DL TOTAL					15.214	6.177	93.98

HORIZONTAL WEDGE LOADS:	P HOR.	P VERT.	D	M
L.E.P. SOIL (DRIVING)	-3.538		4.33	-15.33
VERTICAL COMPONENT		0.00	0.00	0.00
LATERAL WATER (DRIVING)	-0.54		1.67	-0.90
SURCHARGE (DRIVING)	0.00		0.00	0.00
L.E.P. SOIL + SURCHARGE (RESISTING)	0.11		0.67	0.07
VERTICAL COMPONENT (NOT COMPUTED)		0.00	0.00	0.00
LATERAL WATER (RESISTING)	0.000		0.00	0.00
UPLIFT		-1.18	7.33	-8.67
SUBTOTAL ——>	-3.97	14.03	4.93	69.2
ADDITIONAL LOADS				
HIGHWAY L.L. SURCHARGE - FM BACKFILL	-1.18		6.30	-7.45
- VERT. ON STRUCTURAL WEDGE		0.00	7.250	0.00
SURCHARGE (STRUCTURAL WEDGE - Vs)		0.00	7.25	0.00
TOTAL ——>	-5.15	14.03	4.40	61.71

TOTAL WEIGHT OF STRUCTURAL WEDGE = 14.03 kips

MAR 5 1992
CWE
TB

OVERTURNING STABILITY ANALYSIS

Xr= SUM MOMENT ABOUT TOE/SUM OF VERTICAL FORCES
SUM MOM= 61.7 F-kips
Pvert = 14.03 kips $\bar{X}$ = 4.40 FT.

ECCENTRICITY e= HT/2-$\bar{X}$ = 1.10 < 1.83 = HT/6

% BASE IN COMP.= 3*X/HT =" 100.0 %

CRITERIA SATISFIED

SLIDING STABILITY ANALYSIS

N' = Vsum = 14.03 kips T = Hsum = 5.15 kips
0 = 28.00 L = % BASE IN COMPRESSION * HT = 11.00
C = 0.00 FS = 1.33

N'*TAN0/FS (NO COHESION INCLUDED) = 5.60 kips

RESISTING SOIL FORCE REQUIRED = 0.00 kips

ALLOW. PASSIVE SOIL + SURCHARGE = 0.31 kips
AT REST SOIL + SURCHARGE = 0.11 kips

FS = 1.45 -> SLIDING CRITERIA IS SATISFIED

CHECK BEARING CAPACITY

BEARING CAPACITY = Q EQU. 5-2
Q= $\bar{B}$[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB(§m-f)Nr)/2]

ECCEN. OF LOAD e= 1.10

EFFECTIVE WIDTH OF BASE $\bar{B}$= HT-2e = 8.80

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502
Nq = 20.63
Nc = 32.67
Nr = 18.56

EMBEDMENT FACTORS
Ecd =1+0.2(V5/$\bar{B}$)TAN(45+0/2) = 1.084 EQU.5-4a
Eqd=Erd = = 1.000 EQU.5-4b IF(0 = 0)
Eqd=Erd =1+0.1(V5/$\bar{B}$)TAN(45+0/2) = EQU.5-4c IF(0 >10)
Eqd=Erd = = 1.042 FOR (0<0<=10)
INTERPOLATE BETWEEN EQU. 5-4b AND 4c

INCLINATION FACTORS
§o = ARCTAN[(SUM H)/SUM V] = 20.15 DEG.
Eqi=Eci =(1-§o/90)^2 = 0.602 EQU.5-5a
Eri =IF §o > FRIC. ANGLE(0) THEN Eri = 0, ELSE,
Eri =(1-§o/0)^2 = 0.123 EQU.5-5b

BASE TILT FACTORS (A2 IN RADIANS)
Eqt=Ert =(1-a2*TAN0)^2 = 1.000 EQU.5-6a
Ect =1-(2*a2/PI+2) EQU.5-6b (IF 0 =0)
Ect =Eqt-[(1-Eqt)/(NcTAN0)] EQU.5-6c (IF 0 >0)
Ect = 1.000

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992

CWB
BBS

GROUND SLOPE FACTORS

```
        Erg-Eqg -[1-TAN(-B3)]^2 -                 1.000 EQU.5-7a
            Ecg -1-[2*(-B3)/(PI+2)]  (B3 IN RAD.)       EQU.5-7b (IF 0 -0)
            Ecg -Eqg-[(1-Eqg)/Nc*TANO]                  EQU.5-7d (IF 0 >0)
            Ecg -                                 1.000
```

EFFECTIVE OVERBURDEN PRESSURE

```
                qo -(§3*V5+RIPRAP)*COS/B3/ -      0.240 EQU.5-8a

                BEARING CAPACITY -   32.79 kips      EQU. 5-2
                                    ---------
                  F.O.S. -Q/SUM V-     2.3           EQU. 5-1
                                    ---------
```

BEARING CAPACITY IS SATISFIED

BASE PRESSURES DISTRIBUTION (FOOTING)

```
p1- P/HT*(1+6*e/HT) -      IF e IS IN MIDDLE 1/3 OF FOOTING
p1 -2*P/(3*(HT/2-e)) -     IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING

p2- P/HT*(1-6*e/HT) -      IF e IS IN MIDDLE 1/3 OF FOOTING
p2 - 0                     IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING
                             DISTANCE TO p2   -      11.00 FT

        p1 -   2.0424 KSF          p2 -   0.5088 KSF
```

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 199?
CWC

STEM DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	f'c=	4.00	REINF.STR.(KSI)fy=	60.00
COVER TO C.G. REINF.(IN)		3.50	LOAD FACTOR	1.66
WALL INCREMENT (FT)		1.00	STR. REDUCT FACTOR	0.90
As max based on p max =		1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE ABOVE FT TOP (FT)	WALL THICK. (IN)	d (IN)	ULT. MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
0.00	18.00	14.50	27.68	0.43	0.58	0.19	0.58
1.00	18.00	14.50	21.44	0.33	0.58	0.19	0.45
2.00	18.00	14.50	16.26	0.25	0.58	0.19	0.34
3.00	18.00	14.50	12.01	0.19	0.58	0.19	0.25
4.00	18.00	14.50	8.57	0.13	0.58	0.19	0.19
5.00	18.00	14.50	5.84	0.09	0.58	0.19	0.19
6.00	18.00	14.50	3.75	0.06	0.58	0.19	0.19
7.00	18.00	14.50	2.20	0.03	0.58	0.19	0.19
8.00	18.00	14.50	1.14	0.02	0.58	0.19	0.19
9.00	18.00	14.50	0.46	0.01	0.58	0.19	0.19
10.00	18.00	14.50	0.11	0.00	0.58	0.19	0.19
11.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
12.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
13.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
14.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
15.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
16.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
17.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
18.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
19.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
20.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
21.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
22.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (STEM)

STR. RED FACTOR 0= 0.85

Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 2/3*0*Vc ACI 12.10.5.1
AT CUT OF POINT

DISTANCE ABOVE FT BOTT (FT)	WALL THICK. (IN)	D (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
0.00	18.00	14.50	6.80	22.01	18.71

MAR 5 1992
CWB
B65

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

HEEL DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	1.00	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	3.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE FROM HEEL BACK (FT)	HEEL THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
7.500	18.00	14.50	25.73	0.40	0.58	0.19	0.54
6.500	18.00	14.50	20.73	0.32	0.58	0.19	0.43
5.500	18.00	14.50	15.84	0.25	0.58	0.19	0.33
4.500	18.00	14.50	11.28	0.17	0.58	0.19	0.23
3.500	18.00	14.50	7.23	0.11	0.58	0.19	0.19
2.500	18.00	14.50	3.90	0.06	0.58	0.19	0.19
1.500	18.00	14.50	1.48	0.02	0.58	0.19	0.19
0.500	18.00	14.50	0.17	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (HEEL)

STR. RED FACTOR 0=	0.85	Vc = 2*(f'c)^.5*b*d	ACI EQU.(11-3)
		ULT.SHEAR < 0*Vc	ACI 12.10.5.1

DISTANCE U BACK (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
7.50	18.00	14.50	5.00	22.01	18.71

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 19
CWE

TOE DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	0.50	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	4.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.15 in^2	MAX CRACK MOMENT	25.61

DISTANCE FROM TOE (FT)	TOE THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
2.00	18.00	13.50	5.77	0.10	0.54	0.19	0.19
1.50	18.00	13.50	3.28	0.05	0.54	0.19	0.19
1.00	18.00	13.50	1.48	0.02	0.54	0.19	0.19
0.50	18.00	13.50	0.37	0.01	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19

CHECK SHEAR (TOE)

STR. RED FACTOR 0= 0.85 — Vc = 2*(f'c)^.5*b*d — ACI EQU.(11-3)
ULT.SHEAR < 0*Vc — ACI 12.10.5.1

DISTANCE FROM TOE (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
2.00	18.00	13.50	5.64	20.49	17.42

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

RETAINING WALL DESIGN 02/12/92

MAR 5 1992

BASED ON ENGINEER MANUAL EM 1110-2-2502
VERSION WITH RESISTING SOIL CHECK

CWB 1065

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                         WALL SECTION PROPERTIES
TOTAL HEIGHT,VT (FT.)          12.600 HEEL DEPTH @ BACK,V8 (FT)      1.500
FOOTING DEPTH TOE,V1 (FT.)      1.500 STEM BATTER                    0.0625
STEM HEIGHT,V2 (FT.)           11.100 WALL WIDTH AT TOP,H1 (FT.)     1.500
STRAIGHT WALL HT.,V3 (FT.)     11.100 WALL WIDTH AT BOT.,H2 (FT.)    1.500
SLOPED WALL HT., V4 (FT.)       0.000 WALL SLOPE,H3 (FT.)            0.000
B.O.F. TO T.O.S., V5 (FT.)      2.000 FOOTING TOE WIDTH,H4 (FT.)     2.000
SOIL DEPTH, V6 (FT.)            0.500 FOOTING HEEL WIDTH,H5 (FT.)    7.500
FOOTING DEPTH HEEL, V7(FT)      1.500 FOOTING WIDTH,HT (FT.)        11.000
                                      UNIT WEIGHT CONC.,(K/CUFT)     0.150
DEPTH OF RIPRAP IN CHANNEL      0.000 UNIT WEIGHT RIPRAP,(K/CUFT)    0.135
--------------------------------------------------------------------------------
                     ADDITIONAL VERTICAL LOADS
LOADS ON BACKFILL                        LOADS ON STRUCTURAL WEDGE ***
 HIGHWAY L.L. SURCHARGE         2.000 FT   HIGHWAY L.L. SURCHARGE    0.000 FT
 LIVE LOAD SURCHARGE (vd)*      0.000 K/FT LIVE LOAD SURCHARGE       0.000 K/FT
 Vd =                           0.000 K      SURCHARGE (Vs)          0.000 K
 SURCHARGE LOCATION     S =     1.750 FT     DIST. TO F. WALL FACE   5.250 FT
  (DRIVING WEDGE)       X =     0.000 FT SURCHARGE LOCATION   X1=    1.500 FT
LOADS ON RESISTING WEDGE                 FROM F. FACE OF WALL X2=    9.000 FT
 LIVE LOAD SURCHARGE (vr)**     0.000 K/FT
 Vr =                           0.000 K       PARAPET LOAD
 SURCHARGE LOCATION     S =     0.000 FT        -  HEIGHT            0.000 FT
  (RESISTING WEDGE)     X =     0.000 FT        -  WIDTH             0.000 FT
*  A CHECK IS MADE TO DETERMINE IF THE SURCHARGE ON THE BACKFILL WILL
   LIE WITHIN THE INFLUENCE OF THE DRIVING WEDGE.
** IT IS CONSERVATIVE TO NEGLECT SURCHARGES Vr AND Vs.  IF INCLUDED
   ASSURE THEY WILL STAY IN PLACE FOR THE CONDITION ANALYZED.
*** THESE LOADS ARE ASSUMED TO ACT ON THE BACKFILL SIDE OF WALL ONLY.
--------------------------------------------------------------------------------
                      STABILITY  REQUIREMENTS
LOADING CONDITIONS CASE -------->     X
% OF PASSIVE PRESSURE USED       75 SLIDING SAFETY FACTOR           1.01
MIN. BASE AREA IN COMPRESS.      60 BEARING CAP. SAFETY FACTOR      1.50
--------------------------------------------------------------------------------
                         SOIL PROPERTIES (DRIVING WEDGE)
FRICTION ANGLE OF SOIL (01)   33.000 DEG.,(DRIVING WEDGE)
FRICTION ANGLE OF SOIL (02)   33.000 DEG.,(STRUCT. WEDGE)
SLOPE OF BACKFILL RISE/RUN     0.000
BETA ANGLE (B1)                0.000 DEG.
POINT AT WHICH BACKFILL SLOPE BEGINS    2.00 1-SLOPE BEGINS @ STEM
SOIL DEPTH BACK of HEEL(Hz)   12.600           2-SLOPE BEGINS@BACK OF HEEL
STR. MOBILIZATION FACTOR       1.000 (SMF)
SOIL UNIT Wt.,MOIST (§ml)     0.1200 K/CUFT
SOIL UNIT Wt.,SATUR. (§sl)    0.1250 K/CUFT   {ENTER §ml IF NOT SATUR.}
SOIL UNIT Wt.,BOUYANT (§b1)   0.0951 K/CUFT
DEPTH OF CRACK (dc)            0.000 FT.
COHESION ON SLIP PLANE C=      0.000 KSF
COHESION ON SLIP PLANE Cd=     0.000 KSF(DEVELOPED)  = Cd = (SMF)*C

--------------------------------------------------------------------------------
        SOIL OR DRAINAGE FILL PROPERTIES (FOUNDATION MATERIAL)
FRICTION ANGLE OF SOIL (Of)   31.000 DEG. (USED FOR BEARING CAPACITY)
FRICTION ANGLE FOR SLIDING    28.000 DEG. (USED FOR SLIDING ANALYSIS)
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ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5

FOUNDATION MATERIAL	1.000 <———	1 - SOIL FOUNDATION
SOIL UNIT Wt.,MOIST (§m2)	0.115 K/CUFT	2 - ROCK FOUNDATION
SOIL UNIT Wt.,SATUR. (§s2)	0.122 K/CUFT	(ENTER §m2 IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b2)	0.0595 K/CUFT	
COHESION OF FOUNDATION Cfs-	0.000 KSF	(USED FOR SLIDING ANALYSIS)
LENGTH OF COHESION, Cl-	11.000 FT	

UNDERLYING ROCK PROPERTIES

ROCK UNIT Wt., (§r2)	0.0000 K/CUFT	
COHESION OF FOUNDATION Cfr-	0.000 KSF	(USED FOR BEARING CAPACITY)

SOIL PROPERTIES (RESISTING WEDGE)

FRICTION ANGLE OF SOIL (03)	33.000 DEG.	
SLOPE OF OVERLAY,RISE/RUN	0.000	
BETA ANGLE (B3)	0.000 DEG.	
SOIL DEPTH TOE SIDE	2.000 FT.	
SOIL UNIT Wt.,MOIST (§m3)	0.1200 K/CUFT	
SOIL UNIT Wt.,SATUR. (§s3)	0.1250 K/CUFT	(ENTER §m3 IF NOT SATUR.)
SOIL UNIT Wt.,BOUYANT (§b3)	0.0300 K/CUFT	
COHESION ON SLIP PLANE Cr-	0.000 KSF	

WATER PRESSURE PROPERTIES

SATURATION HT. BACKSIDE(hl)	12.00	DIFFERENTIAL HEAD(<h) -	12.00
SATURATION HT.FRONT (h2)	0.00	WATER Ht. ABOVE	
HEIGHT OF MOIST SOIL (hm)	0.60	WATER Ht. IN STREAM(hw)	0.00
WATER UNIT WEIGHT (§w)	0.0625 K/CUFT		

STRUCTURAL CONCRETE PROPERTIES

CONC. STRENGTH (KSI) f'c-	4.00		COVER TO C.G. REINF.(IN)	
REINF.STR.(KSI)fy-	60.00		STEM -	3.50
LOAD FACTOR	1.66		HEEL -	3.50
STR. REDUCT FACTOR	0.90	(MOMENT)	TOE -	4.50
STR. REDUCT FACTOR	0.85	(SHEAR)	p max -	0.00713
WALL INCREMENT (FT)	1.00		p min -	0.00333

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SUMMATION OF MOMENTS ABOUT THE TOE

AREA	VERT.	HORIZ.	WIDTH (FT)	UNIT WT. (K/CU.FT)	P VERT. (K/FT)	D (ARM)	M (FT-kips)
1	11.100	1.500	1.000	0.150	2.498	2.750	6.87
2	0.000	0.000	1.000	0.150	0.000	3.500	0.00
3	1.500	3.500	1.000	0.150	0.788	1.750	1.38
4	1.500	7.500	1.000	0.150	1.688	7.250	12.23
5	0.500	2.000	1.000	0.120	0.120	1.000	0.12
5A	0.000	2.000	1.000	0.125	0.000	1.000	0.00
5B	0.000	2.000	1.000	0.135	0.000	1.000	0.00
5C	0.000	2.000	1.000	0.063	0.000	1.000	0.00
6	0.600	0.000	1.000	0.120	0.000	3.500	0.00
6A	10.500	0.000	1.000	0.125	0.000	3.500	0.00
7	0.000	0.000	1.000	0.120	0.000	0.000	0.00
7A	0.000	0.000	1.000	0.125	0.000	3.500	0.00
8	0.600	7.500	1.000	0.120	0.540	7.250	3.92
8A	10.500	7.500	1.000	0.125	9.844	7.250	71.37
9	0.000	3.750	1.000	0.125	0.000	8.500	0.00
10	0.000	3.750	1.000	0.120	0.000	8.500	0.00
PARAPET	0.000	0.000	1.000	0.150	0.000	2.750	0.00
DL TOTAL					15.476	6.195	95.88

	P HOR.	P VERT.	D	M
HORIZONTAL WEDGE LOADS:				
L.E.P. SOIL (DRIVING)	-2.280		4.25	-9.68
VERTICAL COMPONENT		0.00	0.00	0.00
LATERAL WATER (DRIVING)	-2.15		4.00	-8.61
SURCHARGE (DRIVING)	0.00		0.00	0.00
L.E.P. SOIL + SURCHARGE (RESISTING)	0.11		0.67	0.07
VERTICAL COMPONENT (NOT COMPUTED)		0.00	0.00	0.00
LATERAL WATER (RESISTING)	0.000		0.00	0.00
UPLIFT		-1.97	7.33	-14.47
SUBTOTAL ———>	-4.32	13.50	4.68	63.2
ADDITIONAL LOADS				
HIGHWAY L.L. SURCHARGE - FM BACKFILL	-0.89		6.30	-5.62
- VERT. ON STRUCTURAL WEDGE		0.00	7.250	0.00
SURCHARGE (STRUCTURAL WEDGE - Vs)		0.00	7.25	0.00
TOTAL ———>	-5.21	13.50	4.26	57.58

TOTAL WEIGHT OF STRUCTURAL WEDGE = 13.50 kips

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992
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OVERTURNING STABILITY ANALYSIS

Xr= SUM MOMENT ABOUT TOE/SUM OF VERTICAL FORCES
SUM MOM= 57.6 F-kips
Pvert = 13.50 kips $\bar{X}$ = 4.26 FT.

ECCENTRICITY e= HT/2-$\bar{X}$ = 1.24 < 1.83 = HT/6

% BASE IN COMP.= 3*X/HT =" 100.0 %

CRITERIA SATISFIED

SLIDING STABILITY ANALYSIS

N' = Vsum = 13.50 kips T = Hsum = 5.21 kips
0 = 28.00 L = % BASE IN COMPRESSION * HT = 11.00
C = 0.00 FS = 1.01

N'*TAN0/FS (NO COHESION INCLUDED) = 7.11 kips

RESISTING SOIL FORCE REQUIRED = 0.00 kips

ALLOW. PASSIVE SOIL + SURCHARGE = 0.61 kips
AT REST SOIL + SURCHARGE = 0.11 kips

FS = 1.38 -> SLIDING CRITERIA IS SATISFIED

CHECK BEARING CAPACITY

BEARING CAPACITY = Q EQU. 5-2
Q= $\bar{B}$[(EcdEciEctEcgCNc)+(EqdEqiEqtEqgqoNq)+(ErdEriErtErgB(§m-f)Nr)/2]

ECCEN. OF LOAD e= 1.24

EFFECTIVE WIDTH OF BASE $\bar{B}$= HT-2e = 8.53

BEARING CAPACITY FACTORS FROM TABLE 5-1 EM 1110-2-2502
Nq = 20.63
Nc = 32.67
Nr = 18.56

EMBEDMENT FACTORS
Ecd =1+0.2(V5/$\bar{B}$)TAN(45+0/2) = 1.086 EQU.5-4a
Eqd=Erd = = 1.000 EQU.5-4b IF(0 = 0)
Eqd=Erd =1+0.1(V5/$\bar{B}$)TAN(45+0/2) = EQU.5-4c IF(0 >10)
Eqd=Erd = = 1.043 FOR (0<0<=10)
INTERPOLATE BETWEEN EQU. 5-4b AND 4c

INCLINATION FACTORS
§o = ARCTAN[(SUM H)/SUM V] = 21.12 DEG.
Eqi=Eci =(1-§o/90)^2 = 0.586 EQU.5-5a
Eri =IF §o > FRIC. ANGLE(0) THEN Eri = 0, ELSE,
Eri =(1-§o/0)^2 = 0.102 EQU.5-5b

BASE TILT FACTORS (A2 IN RADIANS)
Eqt=Ert =(1-a2*TAN0)^2 = 1.000 EQU.5-6a
Ect =1-(2*a2/PI+2) EQU.5-6b (IF 0 =0)
Ect =Eqt-[(1-Eqt)/(NcTAN0)] EQU.5-6c (IF 0 >0)
Ect = 1.000

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992
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GROUND SLOPE FACTORS

```
        Erg=Eqg =[1-TAN(-B3)]^2 =             1.000 EQU.5-7a
            Ecg =1-[2*(-B3)/(PI+2)]  (B3 IN RAD.)     EQU.5-7b (IF 0 =0)
            Ecg =Eqg-[(1-Eqg)/Nc*TAN0]                EQU.5-7d (IF 0 >0)
            Ecg =                                 1.000
```

EFFECTIVE OVERBURDEN PRESSURE

```
             qo =(§3*V5+RIPRAP)*COS/B3/ =        0.240 EQU.5-8a

                 BEARING CAPACITY =  30.06 kips      EQU. 5-2
                                     ---------
                  F.O.S. =Q/SUM V=      2.2          EQU. 5-1
                                     ---------
                           BEARING CAPACITY IS SATISFIED
```

BASE PRESSURES DISTRIBUTION (FOOTING)

```
p1= P/HT*(1+6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
p1 =2*P/(3*(HT/2-e)) =      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING

p2= P/HT*(1-6*e/HT) =       IF e IS IN MIDDLE 1/3 OF FOOTING
p2 = 0                      IF e IS OUTSIDE MIDDLE 1/3 OF FOOTING
                              DISTANCE TO p2    =      11.00 FT

        p1 =    2.0550 KSF           p2 =    0.4001 KSF
```

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992

CWB
B

STEM DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI) f'c=	4.00	REINF.STR.(KSI)fy=	60.00
COVER TO C.G. REINF.(IN)	3.50	LOAD FACTOR	1.66
WALL INCREMENT (FT)	1.00	STR. REDUCT FACTOR	0.90
As max based on p max =	1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE ABOVE FT TOP (FT)	WALL THICK. (IN)	d (IN)	ULT. MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
0.00	18.00	14.50	27.84	0.44	0.58	0.19	0.58
1.00	18.00	14.50	21.42	0.33	0.58	0.19	0.45
2.00	18.00	14.50	16.07	0.25	0.58	0.19	0.33
3.00	18.00	14.50	11.69	0.18	0.58	0.19	0.24
4.00	18.00	14.50	8.18	0.13	0.58	0.19	0.19
5.00	18.00	14.50	5.44	0.08	0.58	0.19	0.19
6.00	18.00	14.50	3.39	0.05	0.58	0.19	0.19
7.00	18.00	14.50	1.93	0.03	0.58	0.19	0.19
8.00	18.00	14.50	0.95	0.01	0.58	0.19	0.19
9.00	18.00	14.50	0.37	0.01	0.58	0.19	0.19
10.00	18.00	14.50	0.08	0.00	0.58	0.19	0.19
11.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
12.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
13.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
14.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
15.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
16.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
17.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
18.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
19.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
20.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
21.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19
22.00	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (STEM)

STR. RED FACTOR 0= 0.85 Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 2/3*0*Vc ACI 12.10.5.1
AT CUT OF POINT

DISTANCE ABOVE FT BOTT (FT)	WALL THICK. (IN)	D (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
0.00	18.00	14.50	6.97	22.01	18.71

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992

CWB
TSGS

HEEL DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	1.00	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	3.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.24 in^2	MAX CRACK MOMENT	25.61

DISTANCE FROM HEEL BACK (FT)	HEEL THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
7.500	18.00	14.50	25.96	0.41	0.58	0.19	0.54
6.500	18.00	14.50	20.88	0.33	0.58	0.19	0.43
5.500	18.00	14.50	15.93	0.25	0.58	0.19	0.33
4.500	18.00	14.50	11.33	0.18	0.58	0.19	0.23
3.500	18.00	14.50	7.25	0.11	0.58	0.19	0.19
2.500	18.00	14.50	3.90	0.06	0.58	0.19	0.19
1.500	18.00	14.50	1.48	0.02	0.58	0.19	0.19
0.500	18.00	14.50	0.17	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19
0.000	18.00	14.50	0.00	0.00	0.58	0.19	0.19

CHECK SHEAR (HEEL)

STR. RED FACTOR 0=	0.85	Vc = 2*(f'c)^.5*b*d	ACI EQU.(11-3)
		ULT.SHEAR < 0*Vc	ACI 12.10.5.1

DISTANCE U BACK (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
7.50	18.00	14.50	5.09	22.01	18.71

ROCHESTER 4, 6TH STREET BRIDGE, WALL, U/S RIGHT

MAR 5 1992

CWB
BE

TOE DESIGN (ULTIMATE STRENGTH)

CONC. STRENGTH (KSI)	4.00	REINF. STR.(KSI)	60.00
FOOTING INCREMENTS	0.50	LOAD FACTOR	1.66
COVER TO C.G. REINF.(IN)	4.50	STR. REDUCT FACTOR	0.90
As max based on p max =	1.15 in^2	MAX CRACK MOMENT	25.61

DISTANCE FROM TOE (FT)	TOE THICK. (IN)	d (IN)	ULT MOMENT (F-K)	REQUIRED As (IN^2)	As min. 200/fy (IN^2)	T & S As (IN^2)	DESIGN As (IN^2)
2.00	18.00	13.50	5.81	0.10	0.54	0.19	0.19
1.50	18.00	13.50	3.31	0.05	0.54	0.19	0.19
1.00	18.00	13.50	1.49	0.02	0.54	0.19	0.19
0.50	18.00	13.50	0.38	0.01	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19
0.00	18.00	13.50	0.00	0.00	0.54	0.19	0.19

CHECK SHEAR (TOE)

STR. RED FACTOR 0= 0.85 Vc = 2*(f'c)^.5*b*d ACI EQU.(11-3)
ULT.SHEAR < 0*Vc ACI 12.10.5.1

DISTANCE FROM TOE (FT)	WALL THICK. (IN)	d (IN)	ULT. SHEAR (kip)	Vc SHEAR (kip)	0*Vc SHEAR (kip)
2.00	18.00	13.50	5.68	20.49	17.42

APPENDIX E

RECREATION, LANDSCAPE DEVELOPMENT, AND AESTHETIC CONSIDERATIONS

APPENDIX E

RECREATION, LANDSCAPE DEVELOPMENT,
AND AESTHETIC CONSIDERATIONS

TABLE OF CONTENTS

DESCRIPTION	PAGE
RECREATION	E-1
LANDSCAPE DEVELOPMENT AND AESTHETIC CONSIDERATIONS	E-1

APPENDIX E

RECREATION, LANDSCAPE DEVELOPMENT, AND AESTHETIC CONSIDERATIONS

RECREATION

1. Multi-use pedestrian/bicycle trails will be constructed as a recreation cost shared feature. The trail parallels the Stage 4 channel modifications on the right bank. It connects with the existing city-wide trail system in the downtown area, downstream, and in Bear Creek Park, upstream. The trail along the upstream levee (stations 00+00L to 18+00L) will connect to an existing trail south of Mayo High School. These trails provide both maintenance and recreational access to the creek; transportation routes; and recreational experiences for bicyclists, walkers and joggers. Three existing pedestrian bridges will be relocated as part of the project. Pedestrian bridges at stations 40+10 and 51+20 connect to existing trails, provide connections between neighborhoods on both banks of Bear Creek, provide access to the trail for left bank residents, and enhance circulation within Slatterly Park. Access to the trail for residents on the right bank occurs at the frequent street endings along the channel. A pedestrian bridge in Bear Creek Park (station 70+00) also performs the functions of connection, access and circulation.

2. To avoid conflicts with traffic, underpasses have been provided under bridges at 4th Street, 6th Street and Highway 14. Auxiliary trails are supplied from the 4th and 6th Street bridges to the main trail. These trails facilitate access for residents on the left bank. They also provide an alternate route in flood events when the underpasses are inundated. Safety railings will be furnished where the trail leaves the top of bank to continue under the bridges. Lights will be placed at approximately 100-foot intervals along the trail downstream of Highway 14. Security lights will also be installed under all three bridges.

3. Upstream of Highway 14, the project is located almost entirely in Bear Creek Park, which is a Land and Water Conservation (LAWCON) park. LAWCON legislation of 1965 as amended by Section 6(f) of P.L. 95-42 in 1977, stipulates that any park land converted to a non-recreational use must be replaced in kind. Care has been taken in the design to minimize impacts to the park by the project. Coordination is ongoing with the National Park Service through the Minnesota Department of Trade and Economic Development to assess the amount of replacement land needed.

LANDSCAPE DEVELOPMENT AND AESTHETIC CONSIDERATIONS

4. Concrete treatment, railing, lighting and site furnishings will be consistent with other stages.

5. Drop structures are a prominent feature of the landscape, both upstream and downstream. The design work will consider treatments that minimize negative visual impacts and maximize safety.

6. Plantings compensate for the large amount of vegetation that must be removed to construct the project. They provide pools of shade for trail and park users. The plant materials are chosen for hardiness, visual interest and a variety of experience, both seasonal and spatial. They are located to augment and blend into existing trees; highlight entrances to trail and park; and screen, filter, direct and frame views. In some areas, plants are used to separate the public trail from private residences. Ease of maintenance is a consideration both for plant selection and placement.

7. Vegetation of channel banks has been designed to enhance the recreational experience of Slatterly Park. Banks of the low flow channel will be armored by interlocking concrete blocks. These blocks will have grasses growing in the voids. The bench and banks of the high flow channel will be turf grasses. These measures will improve the visual quality and accessibility to Bear Creek. Visual quality in residential areas of Bear Creek is improved by placement of topsoil and grasses over the riprap above the 20-year flood elevation. Consideration will be given to providing a means of watering these grasses due to the limited volume of soil (and therefore limited resources) they have to draw upon. Irrigation or other means of providing water will be included in the project at the request of the local sponsor as a betterment item.

APPENDIX F

DETAILED ESTIMATE OF COST

APPENDIX F

DETAILED ESTIMATE OF COST

TABLE OF CONTENTS

PARAGRAPH	DESCRIPTION	PAGE
1	GENERAL	F-1
2	Description of Work	F-1
3	Construction Methods	F-1
4	PRICE LEVEL	F-1
5	CONTINGENCIES	F-1
	Relocations	F-2
	Roads, Railroads and Bridges	F-2
	Channels and Cannals	F-2
	Levees and Floodwalls	F-2
	Recreation Facilities	F-2
	Diversion Structures	F-2
	Planning, Engineering & Design	F-2
	Construction Management	F-2
	TOTAL PROJECT COST SUMMARIES	F-3
	FDM ESTIMATE	F-4

APPENDIX F

DETAILED ESTIMATE OF COST
Dated 23 April 1992

GENERAL

1. This is a summary of the current working estimate presented in accordance with EC 1110-2-538, "Civil Works Project Cost Estimating - Code of Accounts". It has been prepared as part of Feature Design Memorandum No. 6 and replaces the Baseline Cost Estimate dated 5 January 1990. A detailed estimate had been prepared using the M-CACES software.

DESCRIPTION OF WORK

2. Description of Work. Work is channel improvements. The channel will be excavated and slopes and some retaining walls constructed to improve flow and provide protection for overtopping. Similar work is under construction as part of Stage 2B. Principal features of work include utility relocations, reconstruction of three pedestrian bridges, channel excavation, two concrete drop structures, tie-in levees, concrete retaining walls, scour protection, pedestrian paths, and landscaping.

CONSTRUCTION METHODS

3. Standard construction methods will be employed for the entire project. Adjacent to walls and bridge underpasses water must be diverted to one bank or the other, must be sumped or pumped with well points and/or deep wells in some locations. Rock excavation may be a combination of mechanical means and blasting. Temporary shoring will be required. Shoring must be anchored because of underlying rock. Rock excavation will be required for some utility relocations.

PRICE LEVEL

4. Estimated costs are based on October 1992 prices and include profit. Calculation of the Fully Funded Estimate (FFE) was done using guidance and indexing factors provided by CENCS-PO. Line item amounts and contingencies have been rounded to the nearest $100, features to the nearest $1,000.

CONTINGENCIES

5. After review of project documents and discussion with engineers, contingencies were developed which reflect the uncertainties associated with each item. Per EC 1110-2-263, these contingencies are based on uncertainties in quantities, unit pricing and unanticipated items of work not defined or recognized at the time of design. Generally, the levels of uncertainty used in this estimate are 5% to 15% for quantity variations, 5% for unit prices, and 5% for unanticipated work, resulting in contingenies generally from 15% to 25%. This contingency range is used throughout the estimate except as described below.

a. Relocations: Contingencies for bridges, streets, sewer, natural gas, electrical relocations average 25%. This is based on past experience for similar projects and reflects uncertainties in quantities, unit prices and scope of work.

b. Roads, Railroads and Bridges: Contingencies average 20%. This reflects uncertainties in quantities, unit prices and scope of work.

c. Channels and Canals: Average 19%. Common excavation, 18% largely to reflect uncertainties in disposal area location. Rock excavation, 18% to account for uncertain limits of rock. Walls average 25%. This is for uncertainties in unit prices for concrete, quantities for excavation, and requirements for temporary sheeting.

d. Levees and Floodwalls: Average 20%. This reflects uncertainties in quantities and unit prices.

e. Recreation Facilities: Average 24%. This is for uncertainties in quantities and unit prices.

f. Diversion Structures: Average 30%. This reflects uncertainties in quantities and prices.

g. Planning, Engineering & Design: Contingencies are assigned by the individual branch chief, section chief or team leader who was responsible for developing the estimated amount. Contingencies in general are 15% for future work. Approximately half the estimated amount will be expended by October 1992.

h. Construction Management: The amount has been estimated by CENCS-CO-CO and includes contingencies of approximately 5%.

TOTAL - ROCHESTER, STAGE 4

**** TOTAL PROJECT COST SUMMARIES ****

PROJECT: ROCHESTER, STAGE 4 , DM No. 6 ESTIMATE
LOCATION: ROCHESTER, MINNESOTA
DATE PREPARED: 23 APRIL 1992

PREPARED BY: GRS , CENCS-ED-C
REVIEWED AND APPROVED BY: Allen L. Hueg , CHIEF, ED-C

ACCOUNT NUMBER	ITEM DESCRIPTION	ESTIMATED COST($) (EPD)	CONTINGENCY AMOUNT($)	%	TOTAL EST COST (EPD)	OMB INFLATION TO 10/92 %	OMB INFLATION TO 10/92 AMOUNT	MID POINT OF FEATURE	OMB (%) INFLATION (+/-)	INFLATED COST AMOUNT ($)	INFLATED CONTG. AMT. ($)	FULLY FUNDED COST
02---	RELOCATIONS	890,000	222,000	25%	1,112,000	2.1%	1,135,000	Sep-94	6.5%	968,000	241,000	1,209,000
04---	DAMS											
06---	FISH AND WILDLIFE FACILITIES											
08---	ROADS, RAILROADS AND BRIDGES	392,000	77,000	20%	469,000	2.1%	479,000	Sep-94	6.5%	426,000	84,000	510,000
09---	CHANNELS AND CANALS	5,657,000	1,082,000	19%	6,739,000	2.1%	6,881,000	Sep-94	6.5%	6,151,000	1,177,000	7,328,000
11---	LEVEES AND FLOODWALLS	492,000	97,000	20%	589,000	2.1%	601,000	Sep-94	6.5%	535,000	105,000	640,000
12---	DREDGING											
14---	RECREATION FACILITIES	864,000	209,000	24%	1,073,000	2.1%	1,096,000	Sep-94	6.5%	939,000	227,000	1,166,000
15---	FLOODWAY CONTROL AND DIV. STRUCT.	518,000	155,000	30%	673,000	2.1%	687,000	Sep-94	6.5%	563,000	169,000	732,000
	TOTAL CONSTRUCTION COSTS =====>	8,813,000	1,842,000	21%	10,655,000		10,879,000			9,582,000	2,003,000	11,585,000
01---	LANDS AND DAMAGES	2,606,000	391,000	15%	2,997,000	2.1%	3,060,000	Jan-93	1.1%	2,691,000	404,000	3,095,000
30---	PLANNING, ENGINEERING AND DESIGN	2,014,000	173,000	9%	2,187,000	3.8%	2,269,000	Oct-92	6.4%	2,117,000	191,000	2,308,000
31---	CONSTRUCTION MANAGEMENT	648,000	0	0%	648,000	3.8%	672,000	Sep-94	13.6%	765,000	0	765,000
	TOTAL PROJECT COSTS ======>	14,081,000	2,406,000		16,487,000		16,880,000			15,155,000	2,598,000	17,753,000

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
01.-.-.-	LANDS AND DAMAGES							
01.B.-.-	PROJECT PLANNING	LS	0	0	0	0	0.0%	1
01.B.-.-	ACQUISITION							
01.B.1.-	BY GOV'T, DIRECT FEDERAL	OSP	0	0	0	0	0.0%	1
01.B.2.-	BY LOCAL SPONSOR	OSP	47	2,500	117,500	17,600	15.0%	2,3,4
01.B.3.-	BY GOV'T ON BEHALF OF LS	OSP	0	0	0	0	0.0%	1
01.B.4.-	GOV'T REVIEW OF LS ACTIVITIES	OSP	47	1,230	57,800	8,700	15.0%	2,3,4
01.C.-.-	CONDEMNATIONS							
01.C.1.-	BY GOV'T	OSP	0	0	0	0	0.0%	1
01.C.2.-	BY LOCAL SPONSOR	OSP	5	50,000	250,000	37,500	15.0%	2,3,4
01.C.3.-	BY GOV'T ON BEHALF OF LS	OSP	0	0	0	0	0.0%	1
01.C.4.-	GOV'T REVIEW OF LS ACTIVITIES	OSP	5	400	2,000	300	15.0%	2,3,4
01.E.-.-	APPRAISALS							
01.E.1.-	BY GOV'T (IN HOUSE)	OSP	0	0	0	0	0.0%	1
01.E.2.-	BY GOV'T (CONTRACT)	OSP	0	0	0	0	0.0%	1
01.E.3.-	BY LOCAL SPONSOR	OSP	54	1,500	81,000	12,200	15.0%	2,3,4
01.E.4.-	BY GOV'T ON BEHALF OF LS	OSP	0	0	0	0	0.0%	1
01.E.5.-	GOV'T REVIEW OF LS ACTIVITIES	OSP	54	370	20,000	3,000	15.0%	2,3,4
01.F.-.-	PL 91-646 ASSISTANCE							
01.F.1.-	PL 91-646 RELOCATIONS-LS	OSP	12	2,500	30,000	4,500	15.0%	2,3,4
01.F.2.-	FEDERAL REVIEW OF DOCUMENTS	OSP	12	500	6,000	900	15.0%	2,3,4
01.F.3.-	BY GOV'T ON BEHALF OF LS	OSP	0	0	0	0	0.0%	1
01.F.4.-	GOV'T REVIEW OF LS ACTIVITIES	OSP	12	350	4,200	600	15.0%	2,3,4
01.G.-.-	TEMPORARY PERMITS							
01.G.1.-	BY GOV'T	OSP	0	0	0	0	0.0%	1
01.G.2.-	BY LOCAL SPONSOR	OSP	7	3,000	21,000	3,200	15.0%	2,3,4
01.G.3.-	BY GOV'T ON BEHALF OF LS	OSP	0	0	0	0	0.0%	1
01.G.4.-	GOV'T REVIEW OF LS ACTIVITIES	OSP	7	280	2,000	300	15.0%	2,3,4
01.G.5.-	OTHER	OSP	0	0	0	0	0.0%	1
01.G.6.-	DAMAGE CLAIMS	OSP	0	0	0	0	0.0%	1
01.R.-.-	REAL ESTATES RECEIPTS/PAYMENTS							
01.R.1.-	LAND PAYMENTS							
01.R.1.A	BY GOV'T	LS	0	0	0	0	0.0%	1
01.R.1.B	BY LOCAL SPONSOR	LS	1	1,645,000	1,645,000	246,800	15.0%	2,3,4
01.R.1.C	BY GOV'T ON BEHALF OF LS	LS	0	0	0	0	0.0%	1
01.R.1.D	GOV'T REVIEW OF LS ACTIVITIES	OSP	47	150	7,100	1,100	15.0%	2,3,4
01.R.2.-	PL 91-646 ASSISTANCE PAYMENTS							
01.R.2.A	BY GOV'T	LS	0	0	0	0	0.0%	1
01.R.2.B	BY LOCAL SPONSOR	LS	12	30,000	360,000	54,000	15.0%	2,3,4
01.R.2.C	BY GOV'T ON BEHALF OF LS	LS	0	0	0	0	0.0%	1
01.R.2.D	GOV'T REVIEW OF LS ACTIVITIES	LS	12	165	2,000	300	15.0%	2,3,4
01.R.3.-	DAMAGE PAYMENTS							
01.R.3.A	BY GOV'T	LS	0	0	0	0	0.0%	1
01.R.3.B	BY LOCAL SPONSOR	LS	0	0	0	0	0.0%	1

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
01.R.3.C	BY GOV'T ON BEHALF OF LS	LS	0	0	0	0	0.0%	1
01.R.3.D	GOV'T REVIEW OF LS ACTIVITIES	LS	0	0	0	0	0.0%	1
01.R.9.-	OTHER	LS	0	0	0	0	0.0%	1
01.T.-.-	LERRD CREDITS							
01.T.1.-	LAND PAYMENTS	LS	0	0	0	0	0.0%	1
01.T.2.-	ADMINISTRATIVE COSTS	LS	0	0	0	0	0.0%	1
01.T.3.-	PL 91-646 ASSISTANCE	LS	0	0	0	0	0.0%	1
01.T.4.-	ALL OTHER	LS	0	0	0	0	0.0%	1

SUBTOTAL CONSTRUCTION COSTS		$2,605,600	
SUBTOTAL CONTINGENCIES	15.0%		$391,000
TOTAL 01. LANDS AND DAMAGES			$2,996,600

REASONS FOR CONTINGENCIES:

1. NOT APPLICABLE
2. UNKNOWN DUE TO LEGAL COSTS.
3. UNKNOWNS DUE TO LAND PRICES.
4. UNKNOWNS DUE TO QUANTITIES

NOTES:

A. FEDERAL, NONFEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA.
B. UNIT PRICES ARE AT APRIL 1991 PRICE LEVELS
C. TRT = TRACT
D. OSP = OWNERSHIP
E. LS = LUMP SUM

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
02.-.-.-	RELOCATIONS							
02.0.A-	MOBILIZATION AND DEMOBILIZATION	LS	1	17,921.00	17,900	4,500	25.0%	1,3
02.3.2.-	WATER LINES							
02.3.2.Q	RELOCATE HYDRANT (NON-FEDERAL)	EA	2	865.00	1,700	1,000	60.0%	1,4
02.3.2.Q	RELOCATE WATER MAIN	LF	250	55.27	13,800	5,500	40.0%	1,4
02.3.2.-	SANITARY SEWER							
02.3.2.Q	REMOVE 15" SANITARY VCP	LF	230	11.50	2,600	1,000	40.0%	1,4
02.3.2.Q	8" DIP, INSTALL	LF	370	33.00	12,200	4,900	40.0%	1,4
02.3.2.Q	SAN MH 1	EA	1	2425.00	2,400	1,000	40.0%	1,4
02.3.2.Q	SAN MH 2	EA	1	4980.00	5,000	2,000	40.0%	1,4
02.3.2.Q	SAN MH 3	EA	1	4980.00	5,000	2,000	40.0%	1,4
02.3.2.Q	15" RCP	LF	32	19.00	600	200	40.0%	1,4
02.3.2.-	NATURAL GAS LINES							
02.3.2.Q	RELOCATE GAS MAINS	LS	1	160,004.00	160,000	64,000	40.0%	1,4
02.3.2.-	TELEPHONE							
02.3.2.R	RELOCATE BURIED CABLE	LS	1	53,763.00	53,800	21,500	40.0%	1,4
02.3.2.-	ELECTRICAL							
02.3.2.R	RELOCATE OVERHEAD LINES (NON-FEDERAL)	LF	150	15.36	2,300	500	20.0%	1,4
02.1.-.-	BRIDGES							
02.1.K.-	PEDESTRIAN BRIDGE 1, STA 40+15 (NON-FEDERAL)							
02.1.L.-	PREFABRICATED BRIDGE	LF	195	448.00	87,400	17,500	20.0%	1,4
02.1.K.B	STRUCTURAL EXCAVATION	CY	750	6.61	5,000	1,000	20.0%	1,4
02.1.K.C	CONCRETE	CY	180	211.00	38,000	7,600	20.0%	1,4
02.1.K.C	REINFORCEMENT	LB	19,100	0.45	8,600	1,700	20.0%	1,4
02.1.K.B	STRUCTURAL BACKFILL	CY	640	12.00	7,700	1,500	20.0%	1,4
02.1.K.C	STRUCTURAL STEEL	LB	155	1.56	200	0	0.0%	5
02.1.K.C	4" PVC DRAINS	LF	130	9.08	1,200	200	20.0%	1,4
02.1.K.-	PEDESTRIAN BRIDGE 2, STA 51+25 (NON-FEDERAL)							
02.1.L.-	PREFABRICATED BRIDGE	LF	195	448.00	87,400	17,500	20.0%	1,4
02.1.K.B	STRUCTURAL EXCAVATION	CY	750	6.68	5,000	1,000	20.0%	1,4
02.1.K.C	CONCRETE	CY	180	211.00	38,000	7,600	20.0%	1,4
02.1.K.C	REINFORCEMENT	LB	19,100	0.45	8,600	1,700	20.0%	1,4
02.1.K.B	STRUCTURAL BACKFILL	CY	640	12.00	7,700	1,500	20.0%	1,4
02.1.K.B	STRUCTURAL STEEL	LB	155	1.56	200	0	0.0%	5
02.1.K.C	4" PVC DRAINS	LF	130	9.08	1,200	200	20.0%	1,4
02.1.L.-	PEDESTRIAN BRIDGE 3, STA 70+20 (NON-FEDERAL)							
02.1.K.B	PREFABRICATED BRIDGE	LF	205	448.00	91,800	18,400	20.0%	1,4
02.1.K.C	STRUCTURAL EXCAVATION	CY	750	6.68	5,000	1,000	20.0%	1,4
02.1.K.C	CONCRETE	CY	205	197.00	40,400	8,100	20.0%	1,4
02.1.K.C	REINFORCEMENT	LB	19,100	0.45	8,600	1,700	20.0%	1,4
02.1.K.B	STRUCTURAL BACKFILL	CY	640	12.00	7,700	1,500	20.0%	1,4
02.1.K.C	STRUCTURAL STEEL	LB	155	1.56	200	0	0.0%	5

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
02.1.K.C	4" PVC DRAINS	LF	130	9.08	1,200	200	20.0%	1,4
02.3.2.-	OUTLET MODIFICATIONS							
02.3.2.B	OUTLET 1, STA 6+17R	LS	1	3,144.00	3,100	500	15.0%	1,4
02.3.2.B	OUTLET 2, STA 8+08L	LS	1	5,550.00	5,600	800	15.0%	1,4
02.3.2.B	OUTLET 3, STA 10+22R	LS	1	2,607.00	2,600	400	15.0%	1,4
02.3.2.B	OUTLET 4, STA 10+96L	LS	1	4,236.00	4,200	600	15.0%	1,4
02.3.2.B	OUTLET 5, STA 13+83R	LS	1	2,653.00	2,700	400	15.0%	1,4
02.3.2.B	OUTLET 6, STA 14+23L	LS	1	3,988.00	4,000	600	15.0%	1,4
02.3.2.B	OUTLET 7, STA 16+95R	LS	1	6,174.00	6,200	900	15.0%	1,4
02.3.2.B	OUTLET 7A, STA 23+57L	LS	1	250.00	300	0	0.0%	5
02.3.2.B	OUTLET 8, STA 24+80R	LS	1	20,685.00	20,700	3,100	15.0%	1,4
02.3.2.B	OUTLET 9, STA 26+90L	LS	1	332.00	300	0	0.0%	5
02.3.2.B	OUTLET 10, STA 27+74R	LS	1	1,250.00	1,300	200	15.0%	1,4
02.3.2.B	OUTLET 11, STA 30+93L	LS	1	1,228.00	1,200	200	15.0%	1,4
02.3.2.B	OUTLET 12, STA 31+15R	LS	1	3,667.00	3,700	600	15.0%	1,4
02.3.2.B	OUTLET 13, STA 39+78R	LS	1	1,730.00	1,700	300	15.0%	1,4
02.3.2.B	OUTLET 14, STA 44+50R	LS	1	2,858.00	2,900	400	15.0%	1,4
02.3.2.B	OUTLET 15, STA 45+84R	LS	1	7,085.00	7,100	1,100	15.0%	1,4
02.3.2.B	OUTLET 16, STA 51+49R	LS	1	5,812.00	5,800	900	15.0%	1,4
02.3.2.B	OUTLET 17, STA 61+35R	LS	1	3,985.00	4,000	600	15.0%	1,4
02.3.2.B	OUTLET 18, STA 62+22L	LS	1	374.00	400	0	0.0%	5
02.3.2.B	OUTLET 19, STA 62+22R	LS	1	374.00	400	0	0.0%	5
02.3.2.B	MAYO RUN	LS	1	45,250.00	45,300	6,800	15.0%	1,4
02.3.2.-	OUTLET MANHOLES							
02.3.2.B	OUTLET 1 MANHOLE	LS	1	2,719.00	2,700	400	15.0%	1,4
02.3.2.B	OUTLET 2 MANHOLE	LS	1	6,061.00	6,100	900	15.0%	1,4
02.3.2.B	OUTLET 3 MANHOLE	LS	1	1,765.00	1,800	300	15.0%	1,4
02.3.2.B	OUTLET 4 MANHOLE	LS	1	4,671.00	4,700	700	15.0%	1,4
02.3.2.B	OUTLET 5 MANHOLE	LS	1	3,666.00	3,700	600	15.0%	1,4
02.3.2.B	OUTLET 8 MANHOLE	LS	1	2,578.00	2,600	400	15.0%	1,4
02.3.2.B	OUTLET 13 MANHOLE	LS	1	1,961.00	2,000	300	15.0%	1,4
02.3.2.B	OUTLET 15 MANHOLE	LS	1	4,027.00	4,000	600	15.0%	1,4
02.3.2.B	OUTLET 16 MANHOLE	LS	1	3,591.00	3,600	500	15.0%	1,4
02.3.2.B	OUTLET 8, CATCHBASIN	LS	1	1,212.00	1,200	200	15.0%	1,4
02.3.2.B	OUTLET 17, CATCHBASIN	LS	1	1,536.00	1,500	200	15.0%	1,4
02.3.2.B	OUTLET 18, CATCHBASIN	LS	1	2,015.00	2,000	300	15.0%	1,4
02.3.2.B	OUTLET 19, CATCHBASIN	LS	1	2,015.00	2,000	300	15.0%	1,4

SUBTOTAL CONSTRUCTION COSTS		$889,800	
SUBTOTAL CONTINGENCIES	25.0%		$222,100
TOTAL 02. RELOCATIONS			$1,111,900

REASONS FOR CONTINGENCIES

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. INSIGNIFICANT AMOUNT

NOTES

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1. EXTENSIONS ARE ROUNDED TO THE NEAREST $100
2. FEDERAL, NON FEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
08.-.-.-	ROADS, RAILROADS AND BRIDGES							
08.2.A.-	MOBILIZATION/DEMOBILIZATION							
08.1.A.1	MOBILIZATION/DEMOBILIZATION	LS	1	$7,692.00	7,700	1,900	25.0%	1,3
08.2.K.-	REMOVE WINGWALLS, 6TH ST SE							
08.2.K.B	REMOVE WINGWALLS, 6TH ST SE	LS	1	4,741.00	4,700	1,200	25.0%	1,4
08.2.K.-	WINGWALL @ 4TH ST SE							
08.2.K.B	EXCAVATION	CY	1,290	6.69	8,600	2,200	25.0%	1,4
08.2.K.B	TEMPORARY SHEET PILE	SF	6,000	7.11	42,700	10,700	25.0%	1,4
08.2.K.C	CONCRETE	CY	125	229.00	28,600	7,200	25.0%	1,4
08.2.K.C	REINFORCING STEEL	LB	13,500	0.45	6,100	1,500	25.0%	1,4
08.2.K.B	BACKFILL	CY	650	12.00	7,800	2,000	25.0%	1,4
08.2.K.-	SCOUR PROTECTION 4TH ST							
08.2.K.B	EXCAVATION	CY	40	6.68	300	0	0.0%	5
08.2.K.C	CONCRETE	CY	150	92.25	13,800	2,800	20.0%	1,4
08.2.K.C	REINFORCING STEEL	LB	17,000	0.45	7,700	1,500	20.0%	1,4
08.2.K.B	BACKFILL	CY	200	12.00	2,400	500	20.0%	5
08.2.K.-	WINGWALL EXTENSION ONLY, @ 6TH ST SE							
08.2.K.B	EXCAVATION	CY	550	6.69	3,700	900	25.0%	1,4
08.2.K.B	ROCK EXCAVATION	CY	80	32.90	2,600	700	25.0%	1,4
08.2.K.B	TEMPORARY SHEET PILE	SF	2,340	7.09	16,600	4,200	25.0%	1,4
08.2.K.C	CONCRETE	CY	70	210.00	14,700	3,700	25.0%	1,4
08.2.K.C	REINFORCING STEEL	LB	8,400	0.45	3,800	1,000	25.0%	1,4
08.2.K.B	BACKFILL	CY	350	12.00	4,200	1,100	25.0%	1,4
08.2.K.-	SCOUR PROTECTION 6TH ST							
08.2.K.B	ROCK EXCAVATION	CY	365	32.88	12,000	2,400	20.0%	1,4
08.2.K.C	CONCRETE	CY	155	114.35	17,700	3,500	20.0%	1,4
08.2.K.C	REINFORCING STEEL	LB	12,400	0.45	5,600	1,100	20.0%	1,4
08.2.K.-	WINGWALL EXTENS ONLY, @ HWY 14 EAST - WEST							
08.2.K.B	EXCAVATION	CY	540	6.69	3,600	500	15.0%	1,4
08.2.K.B	TEMPORARY SHEET PILE	SF	4,350	7.11	30,900	4,600	15.0%	1,4
08.2.K.C	CONCRETE	CY	80	180.55	14,400	2,200	15.0%	1,4
08.2.K.C	REINFORCING STEEL	LB	8,800	0.45	4,000	600	15.0%	1,4
08.2.K.B	BACKFILL	CY	410	12.00	4,900	700	15.0%	1,4
08.2.K.-	INTERMEDIATE WALL HWY14							
08.2.K.B	EXCAVATION	CY	500	8.20	4,100	600	15.0%	1,4
08.2.K.B	TEMPORARY SHEET PILING	SF	1,700	7.11	12,100	1,800	15.0%	1,4
08.2.K.C	CONCRETE	CY	100	150.00	15,000	2,300	15.0%	1,4
08.2.K.C	REINFORCING STEEL	LB	12,000	0.45	5,400	800	15.0%	1,4
08.2.K.B	BACKFILL	CY	280	12.00	3,400	500	15.0%	1,4
08.2.K.-	SCOUR PROTECTION HWY 14							
08.2.K.B	EXCAVATION	CY	2,225	6.69	14,900	2,200	15.0%	1,4
08.2.K.C	CONCRETE	CY	460	92.95	42,800	6,400	15.0%	1,4
08.2.K.C	REINFORCING STEEL	LB	55,200	0.45	24,800	3,700	15.0%	1,4

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
	SUBTOTAL CONSTRUCTION COSTS				$391,600			
	SUBTOTAL CONTINGENCIES		19.7%			$77,000		
	TOTAL 08. ROADS, RAILROADS AND BRIDGES					$468,600		

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. INSIGNIFICANT AMOUNT

NOTES

1. EXTENSIONS ARE ROUNDED TO THE NEAREST $100
2. FEDERAL, NON FEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
09.-.-.-	CHANNELS AND CANALS							
09.0.A._	MOBILIZATION AND PREP							
09.0.A.A	MOBILIZATION & DEMOB	LS	1	$109,831	109,800	27,500	25.0%	1,3
09.0.2.-	REMOVALS							
09.0.2.B	1B-3 TEMP. DROP STRUCT.	LS	1	23,179.00	23,200	4,600	20.0%	1,2,4
09.0.2.B	BITUMINOUS PATHS	SY	1,800	1.96	3,500	700	20.0%	1,4
09.0.2.B	CONCRETE PATHS	SY	160	6.22	1,000	200	20.0%	1,4
09.0.2.B	BITUMINOUS PAVEMENT	SY	6,100	1.96	12,000	2,400	20.0%	1,4
09.0.2.B	GUARDRAIL	LF	165	7.66	1,300	300	20.0%	1,4
09.0.2.B	CONCRETE CURB AND GUTTER	LF	255	0.39	100	0	20.0%	1,4
09.0.2.B	CONCRETE WALLS	SF	3,400	3.34	11,400	2,300	20.0%	1,4
09.0.2.B	STONE WALLS	SF	2,800	6.21	17,400	3,500	20.0%	1,4
09.0.2.B	LIMESTONE WALLS	SF	3,100	6.22	19,300	3,900	20.0%	1,4
09.0.2.B	CONCRETE CHANNEL PAVING	SY	525	30.51	16,000	3,200	20.0%	1,4
09.0.2.B	HANDRAIL	LF	350	2.52	900	0	0.0%	5
09.0.2.B	SANITARY MH, PLUG PIPE	LS	2	94.00	200	0	0.0%	5
09.0.2.-	REPLACEMENTS							
09.0.2.B	BITUMINOUS PAVEMENT	SY	900	8.68	7,800	1,600	20.0%	1,4
09.0.2.B	AGGREGATE BASE COURSE	CY	200	129.73	25,900	5,200	20.0%	1,4
09.0.2.B	CURB AND GUTTER	LF	100	3.04	300	0	0.0%	5
09.0.2.B	GUARDRAIL	LF	165	27.50	4,500	900	20.0%	1,4
09.0.2.-	CHANNEL IMPROVEMENT							
09.0.2.B	CLEARING AND GRUBBING	ACR	4	6,085.00	24,300	4,400	18.0%	1,2,4
09.0.2.B	REMOVE ISOLATED TREES	LS	1	78,135.00	78,100	14,100	18.0%	1,2,4
09.0.2.B	EXCAVATION, COMMON	CY	237,200	4.84	1,148,000	206,600	18.0%	1,4
09.0.2.B	EXCAVATION, ROCK	CY	56,200	22.60	1,270,100	228,600	18.0%	1,4
09.0.2.B	STRIPPING TOPSOIL	CY	3,200	2.21	7,100	1,300	18.0%	1,4
09.0.2.B	FILL, RANDOM	CY	29,300	3.55	104,000	18,700	18.0%	1,4
09.0.2.B	BEDDING, TYPE 1	CY	3,800	21.30	80,900	14,600	18.0%	1,4
09.0.2.B	BEDDING, TYPE 2	CY	2,800	21.30	59,600	10,700	18.0%	1,4
09.0.2.B	BEDDING, TYPE 4	CY	4,200	21.30	89,500	16,100	18.0%	1,4
09.0.2.B	RIPRAP, TYPE A	CY	9,100	22.10	201,100	36,200	18.0%	1,4
09.0.2.B	RIPRAP, TYPE B	CY	14,800	22.10	327,100	58,900	18.0%	1,4
09.0.2.B	RIPRAP, TYPE D	CY	2,800	22.71	63,600	11,400	18.0%	1,4
09.0.2.B	RIPRAP, TYPE F	CY	3,600	22.71	81,800	14,700	18.0%	1,4
09.0.2.B	RIPRAP, TYPE G	CY	1,600	22.71	36,300	6,500	18.0%	1,4
09.0.2.B	RIPRAP, TYPE H	CY	3,100	22.71	70,400	12,700	18.0%	1,4
09.0.2.B	TOPSOIL	CY	12,800	2.83	36,200	6,500	18.0%	1,4
09.0.2.B	SEEDING	ACR	11.40	5,722.00	65,200	26,100	40.0%	1,4
09.0.2.B	RIPRAP SURFACE TREATMENT	SY	18,400	2.44	44,900	8,100	18.0%	1,4
09.0.2.B	GEOTEXTILE	SY	17,800	1.35	24,000	4,300	18.0%	1,4
09.0.2.B	INTERLOCKING BLOCK SLOPE PROT.	SY	17,800	46.00	818,800	147,400	18.0%	1,4
09.0.2.-	CONC RETAIN WALL DS 4 ST SE LB @ STA 3+50							
09.0.2.B	STRUCT EXCAVATION	CY	340	5.66	1,900	0	0.0%	5
09.0.2.B	STRUCTURAL BACKFILL	CY	310	6.97	2,200	0	0.0%	5
09.0.2.B	BASE CONCRETE	CY	65	101.00	6,600	1,700	25.0%	1,4

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
09.0.2.B	VERTICAL CONCRETE	CY	60	308.00	18,500	4,600	25.0%	1,4
09.0.2.B	REINFORCING	LB	15,000	0.45	6,800	1,700	25.0%	1,4
09.0.2.B	TEMPORARY SHEET PILE	SF	3,300	7.74	25,500	6,400	25.0%	1,4
09.0.2.B	ANCHORS FOR SHEETPILING	LS	1	24,365.00	24,400	6,100	25.0%	1,4
09.0.2.-	CONC RETAIN WALL DS US 6 ST SE RB LB							
09.0.2.B	STRUCT EXCAVATION	CY	5,500	5.66	31,100	7,800	25.0%	1,4
09.0.2.B	STRUCTURAL EXCAVATION - ROCK	CY	900	22.51	20,300	5,100	25.0%	1,4
09.0.2.B	STRUCTURAL BACKFILL	CY	5,925	6.97	41,300	10,300	25.0%	1,4
09.0.2.B	BASE CONCRETE	CY	355	97.00	34,400	8,600	25.0%	1,4
09.0.2.B	VERTICAL CONCRETE	CY	265	289.00	76,600	19,200	25.0%	1,4
09.0.2.B	REINFORCING	LB	69,300	0.45	31,200	7,800	25.0%	1,4
09.0.2.B	TEMPORARY SHEET PILE	SF	10,120	7.75	78,400	19,600	25.0%	1,4
09.0.2.B	ANCHORS FOR SHEETPILING	LS	1	97,463.00	97,500	24,400	25.0%	1,4
09.0.R.-	LANDSCAPING							
09.0.R.B	TREES	LS	1	274,450.00	274,500	54,900	20.0%	1,4

SUBTOTAL CONSTRUCTION COSTS		$5,656,800	
SUBTOTAL CONTINGENCIES	19.1%		$1,082,400
TOTAL 09. CHANNELS AND CANALS			$6,739,200

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. INSIGNIFICANT AMOUNT

NOTES

1. EXTENSIONS ARE ROUNDED TO THE NEAREST $100
2. FEDERAL, NON FEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
11.-.-.-	LEVEES AND FLOODWALLS							
11.0.A.-	MOB & PREPARATORY WORK							
11.0.A.1	MOBILIZATION/DEMOB	LS	1	$9,600	9,600	2,400	25.0%	1,3
11.0.C.-	PERM ACCESS RDS							
11.0.C.B	BASE AGGREGATE 8" THICK	CY	450	32.29	14,500	2,900	20.0%	1,4
11.0.C.B	BITUMINOUS SURFACE, 3"	CY	169	104.65	17,700	3,500	20.0%	1,4
11.0.C.B	PERMANENT GUARDPOSTS	EA	8	58.00	500	0	0.0%	5
11.0.C.B	REMOVEABLE GUARDPOSTS	EA	4	192.00	800	0	0.0%	5
11.0.1.-	REMOVALS							
11.0.1.B	BIT. PAVEMENT REMOVAL	SY	4,130	4.68	19,300	3,900	20.0%	1,3,4
11.0.1.-	LEVEES							
11.0.1.B	CLEARING AND GRUBBING	ACR	7.70	6,107.00	47,000	9,400	20.0%	1,3,4
11.0.1.B	STRIP TOPSOIL	CY	3,180	1.28	4,100	800	20.0%	1,3,4
11.0.1.B	COMMON EXCAVATION	CY	6,700	3.02	20,200	4,000	20.0%	1,4
11.0.1.B	INSPECTION TRENCH	LF	3,700	8.04	29,700	5,900	20.0%	1,4
11.0.1.B	RANDOM FILL	CY	13,500	1.70	23,000	4,600	20.0%	1,4
11.0.1.B	BEDDING, TYPE 2	CY	1,500	21.38	32,100	6,400	20.0%	1,4
11.0.1.B	RIPRAP, TYPE B	CY	3,000	22.12	66,400	13,300	20.0%	1,4
11.0.1.B	RIPRAP SURFACE TREATMENT	SY	5,900	2.45	14,500	2,900	20.0%	1,4
11.0.1.B	TOPSOIL	CY	5,900	5.76	34,000	6,800	20.0%	1,4
11.0.1.B	SEEDING	ACR	6.00	2,200.00	13,200	2,600	20.0%	1,4
11.0.G.-	CULVERT @ STA 18+50.00 (LEFT TIE-BACK LEVEE)							
11.0.G.B	STRUCTURAL EXCAVATION	CY	165	5.68	900	0	0.0%	5
11.0.G.B	STRUCTURAL BACKFILL	CY	210	11.00	2,300	400	17.0%	1,4
11.0.G.E	FLAPGATE, 48" DIAMETER	EA	1	10,200.00	10,200	1,700	17.0%	4
11.0.G.B	48" DIAMETER RCP	LF	66	105.40	7,000	1,200	17.0%	1,4
11.0.G.B	48" FLARED INTAKE	EA	1	421.56	400	0	0.0%	5
11.0.G.B	TRASH GUARD	EA	1	1,282.00	1,300	200	17.0%	1,4
11.0.G.C	HEADWALLS, CONCRETE	CY	20	306.00	6,100	1,000	17.0%	1,4
11.0.G.E	HEADWALLS,REINFORCEMENT	LB	3,250	0.45	1,500	0	0.0%	5
11.0.G.B	EXCAVATION	CY	650	3.02	2,000	300	17.0%	1,4
11.0.G.B	RIPRAP, TYPE F	CY	105	22.12	2,300	400	17.0%	1,4
11.0.G.B	RIPRAP, TYPE B	CY	60	22.12	1,300	200	17.0%	1,4
11.0.G.B	BEDDING, TYPE 1	CY	30	21.38	600	0	0.0%	5
11.0.G.B	BEDDING, TYPE 2	CY	50	21.38	1,100	200	17.0%	1,4
11.0.G.B	TOPSOIL	CY	130	2.84	400	0	0.0%	5
11.0.G.B	SEED	AC	0.15	2200.00	300	0	0.0%	5
11.0.R.-	LANDSCAPING							
11.0.R.B	TREES	LS	1	108,000.00	108,000	21,600	20.0%	1,4

SUBTOTAL CONSTRUCTION COSTS		$492,300	
SUBTOTAL CONTINGENCIES	19.6%		$96,600

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
	TOTAL 11. LEVEES AND FLOODWALLS					$588,900		

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. INSIGNIFICANT AMOUNT

NOTES

1. EXTENSIONS ARE ROUNDED TO THE NEAREST $100
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ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
14.-.-.-	RECREATION FACILITIES							
14.0.A.-	MOBILIZATION AND PREP							
14.0.A.B	MOB/DEMOB	LS	1	$16,900	16,900	4,200	25.00%	1,3
14.0.3.-	BITUMINOUS PATH, 5+10 - 76+00							
14.0.3.B	BITUMINOUS PATH	SY	9,400	8.98	84,400	16,900	20.0%	1,4
14.0.3.-	CONCRETE PATH UNDERPASS US 14							
14.0.3.B	STRUCT EXCAVATION	CY	150	5.67	900	0	0.0%	5
14.0.3.B	STRUCTURAL BACKFILL	CY	60	6.99	400	0	0.0%	5
14.0.3.B	COARSE DRAINAGE FILL	EA	470	31.42	14,800	3,000	20.0%	1,4
14.0.3.B	BASE CONCRETE	CY	130	95.79	12,500	2,500	20.0%	1,4
14.0.3.B	VERTICAL CONCRETE	CY	60	330.39	19,800	4,000	20.0%	1,4
14.0.3.B	REINFORCING	LB	19,050	0.45	8,600	1,700	20.0%	1,4
14.0.3.B	CONCRETE PATHS	SY	560	82.05	45,900	9,200	20.0%	1,4
14.0.3.B	HANDRAIL/BICYCLE	LF	420	50.95	21,400	4,300	20.0%	1,4
14.0.3.-	CONCRETE PATH UNDERPASS 6TH ST SE							
14.0.3.B	STRUCT EXCAVATION	CY	55	5.67	300	0	0.0%	5
14.0.3.B	VERTICAL CONCRETE	CY	120	212.00	25,400	5,100	20.0%	1,4
14.0.3.B	REINFORCING	LB	12,000	0.45	5,400	1,100	20.0%	1,4
14.0.3.B	CONCRETE PATHS	SY	840	66.38	55,800	11,200	20.0%	1,4
14.0.3.B	HANDRAIL/BICYCLE	LF	630	50.95	32,100	6,400	20.0%	1,4
14.0.3.-	CONCRETE PATH UNDERPASS 4TH ST SE							
14.0.3.B	STRUCT EXCAVATION	CY	215	5.67	1,200	200	20.0%	1,4
14.0.3.B	STRUCTURAL BACKFILL	CY	60	6.99	400	0	0.0%	5
14.0.3.B	COARSE DRAINAGE FILL	EA	490	31.42	15,400	3,100	20.0%	1,4
14.0.3.B	BASE CONCRETE	CY	135	98.00	13,200	2,600	20.0%	1,4
14.0.3.B	VERTICAL CONCRETE	CY	57	375.00	21,400	4,300	20.0%	1,4
14.0.3.B	REINFORCING	LB	20,340	0.45	9,200	1,800	20.0%	1,4
14.0.3.B	CONCRETE PATHS	SY	970	66.38	64,400	12,900	20.0%	1,4
14.0.3.B	HANDRAIL/BICYCLE	LF	730	50.95	37,200	7,400	20.0%	1,4
14.0.6.R	AREA LIGHTING							
14.0.6.B	LIGHTING	LS	1	243,280	243,300	73,000	30.0%	1,4
14.0.2.B	LANDSCAPING							
14.0.2.B	TREES	LS	1	102,435	102,400	30,700	30.0%	1,4
14.0.2.B	SHRUBS	LS	1	11,013	11,000	3,300	30.0%	1,4

SUBTOTAL CONSTRUCTION COSTS		$863,700	
SUBTOTAL CONTINGENCIES	24.2%		$208,900
TOTAL 14. RECREATION FACILITIES			$1,072,600

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
						===========		

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. INSIGNIFICANT AMOUNT

NOTES

1. EXTENSIONS ARE ROUNDED TO THE NEAREST $100
2. FEDERAL, NON FEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	PERCENT	REASON
15.-.-.-	DIVERSION STRUCTURES							
15.0.A.-	MOB/DEMOB & PREP							
15.0.A.1	MOB/DEMOB & PREP	LS	1	$10,255	10,300	2,600	25.0%	1,3
15.0.1.-	UPSTREAM DROP STRUCTURE							
15.0.D.B	SHEET PILING	SF	2,150	12.24	26,300	7,900	30.0%	1,4
15.0.D.B	STRUCTURAL EXCAVATION	CY	3,000	1.42	4,300	1,300	30.0%	1,4
15.0.D.B	DEWATERING	LS	1	38,453.00	38,500	11,600	30.0%	1,4
15.0.D.B	STRUCTURAL BACKFILL	CY	4,360	3.28	14,300	4,300	30.0%	1,4
15.0.1.C	BASE CONCRETE	CY	530	121.00	64,100	19,200	30.0%	1,4
15.0.1.C	VERTICAL CONCRETE	CY	410	234.00	95,900	28,800	30.0%	1,4
15.0.1.C	REINFORCEMENT	LB	121,000	0.45	54,500	16,400	30.0%	1,4
15.0.1.C	FENCE	LF	230	39.34	9,000	2,700	30.0%	1,4
15.0.1.-	DOWNSTREAM DROP STRUCT							
15.0.D.B	STRUCTURAL EXCAVATION	CY	550	1.42	800	0	0.0%	5
15.0.D.B	DEWATERING	LS	1	38,453.00	38,500	11,600	30.0%	1,4
15.0.D.B	STRUCT ROCK EXCAVATION	CY	1,250	24.65	30,800	9,200	30.0%	1,4
15.0.D.B	COARSE DRAINAGE FILL	CY	100	31.59	3,200	1,000	30.0%	1,4
15.0.D.B	STRUCTURAL BACKFILL	CY	615	14.10	8,700	2,600	30.0%	1,4
15.0.1.C	BASE CONCRETE	CY	300	109.00	32,700	9,800	30.0%	1,4
15.0.1.C	VERTICAL CONCRETE	CY	210	271.00	56,900	17,100	30.0%	1,4
15.0.1.C	REINFORCEMENT	LB	57,000	0.45	25,700	7,700	30.0%	1,4
15.0.R.E	FENCE	LF	96	39.34	3,800	1,100	30.0%	1,4
	SUBTOTAL CONSTRUCTION COSTS				$518,300			
	SUBTOTAL CONTINGENCIES		29.9%			$154,900		
	TOTAL 15. FLOODWAY CONTROL AND DIVERSION STRUCTURES					$673,200		

REASONS FOR CONTINGENCIES

1. QUANTITY UNKNOWNS
2. UNKNOWN SITE CONDITIONS
3. UNKNOWN HAUL DISTANCE
4. UNIT PRICE UNKNOWNS
5. INSIGNIFICANT AMOUNT

NOTES

1. EXTENSIONS ARE ROUNDED TO THE NEAREST $100
2. FEDERAL, NON FEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
30.-.-.-	PLANNING, ENGINEERING AND DESIGN							
30.B.-.-	ENGINEERING AND DESIGN FOTR FDM							
30.B.4.-	FDM EXPENDITURES PRIOR TO 04/92	LS	1	$863.700	863,700	0	0.0%	1
30.B.4.-	FDM ESTIMATED REMAINING EXPENDITURES	LS	1	160,000	160,000	24,000	15.0%	
30.G.F.-	VALUE ENGINEERING (VE) STUDIES							
30.G.F.-	ED-EJ	LS	1	24,000	24,000	3,600	15.0%	1
30.G.F.-	ED-ES	LS	1	24,000	24,000	3,600	15.0%	1
30.G.F.-	ED-FD	LS	1	10,000	10,000	1,500	15.0%	1
30.G.F.-	ED-FE	LS	1	24,000	24,000	3,600	15.0%	1
30.G.F.-	PD-ER	LS	1	3,000	3,000	500	15.0%	1
30.G.F.-	PD-ES	LS	1	3,000	3,000	500	15.0%	1
30.G.F.-	ED-EN	LS	1	4,200	4,200	600	15.0%	1
30.G.F.-	ED-EG	LS	1	4,500	4,500	700	15.0%	1
30.H.-.-	PLANS AND SPECIFICATIONS							
30.H.-.-	ED-EG	LS	1	15,600	15,600	2,300	15.0%	1
30.H.-.-	ED-EF	LS	1	46,300	46,300	6,900	15.0%	1
30.H.-.-	ED-EJ	LS	1	171,400	171,400	25,700	15.0%	1
30.H.-.-	ED-ER	LS	1	12,000	12,000	1,800	15.0%	1
30.H.-.-	ED-ES	LS	1	161,800	161,800	24,300	15.0%	1
30.H.-.-	ED-FB	LS	1	48,500	48,500	7,300	15.0%	1
30.H.-.-	ED-FD	LS	1	48,500	48,500	7,300	15.0%	1
30.H.-.-	ED-FE	LS	1	24,800	24,800	3,700	15.0%	1
30.H.-.-	ED-FF	LS	1	2,800	2,800	400	15.0%	1
30.H.-.-	PD-ER	LS	1	20,100	20,100	3,000	15.0%	1
30.H.-.-	PD-ES	LS	1	28,000	28,000	4,200	15.0%	1
30.H.-.-	ED-EN	LS	1	39,300	39,300	5,900	15.0%	1
30.N.-.-	CONSTRUCTION/SUPPLY CONTRACT AWARD ACT.							
30.N.-.-	ED-EF	LS	1	20,000	20,000	3,000	15.0%	1
30.N.-.-	ED-EJ	LS	1	20,000	20,000	3,000	15.0%	1
30.N.-.-	ED-ER	LS	1	4,000	4,000	600	15.0%	1
30.N.-.-	ED-ES	LS	1	52,000	52,000	7,800	15.0%	1
30.N.-.-	ED-FB	LS	1	15,000	15,000	2,300	15.0%	1
30.N.-.-	ED-FD	LS	1	30,000	30,000	4,500	15.0%	1
30.N.-.-	ED-FE.	LS	1	14,000	14,000	2,100	15.0%	1
30.N.-.-	PD-ER	LS	1	8,000	8,000	1,200	15.0%	1
30.N.-.-	PD-ES	LS	1	7,000	7,000	1,100	15.0%	1
30.N.-.-	ED-EN	LS	1	9,000	9,000	1,400	15.0%	1
	ED-EG	LS	— 1	11,000	11,000	1,700	15.0%	1
30.P.-.-	PROJECT MANAGEMENT							
30.P.-.-	LCPM-JR	LS	1	84,300	84,300	12,600	14.9%	1
	SUBTOTAL CONSTRUCTION COSTS				$2,013,800			
	SUBTOTAL CONTINGENCIES		8.6%			$172,700		
	TOTAL 30. PLANNING, ENGINEERING AND DESIGN					$2,186,500		

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON

REASONS FOR CONTINGENCIES

1. UNKNOWNS DUE TO MANHOURS REQUIRED.

NOTES:

A. FEDERAL, NONFEDERAL COST ARE TO BE IN ACCORDANCE WITH 1986 WRDA.

ACCOUNT CODE	ITEM	UNIT	QUANTITY	UNIT PRICE	AMOUNT	CONTINGENCIES AMOUNT	CONTINGENCIES PERCENT	REASON
31.-.-.-	CONSTRUCTION MANAGEMENT (S&I)							
31.B.-.-	CONTRACT ADMINISTRATION							
31.B.3.-	REVIEW AND PAY APP ESTIMATES	LS	1	19,440	19,400	0	0.0%	1
31.B.4.-	CONTRACT MODS	LS	1	38,880	38,900	0	0.0%	1
31.B.5.-	PROG AND COMP RPTS	LS	1	9,720	9,700	0	0.0%	1
31.B.9.-	ALL OTHER ACTIVITIES	LS	1	116,640	116,600	0	0.0%	1
31.B.Z.-	CONTINGENCIES	LS	1	9,720	9,700	0	0.0%	1
31.D.-.-	REVIEW OF SHOP DRAWINGS	LS	1	32,400	32,400	0	0.0%	1
31.D.Z.-	CONTINGENCIES	LS	1	1,620	1,600	0	0.0%	1
31.E.-.-	INSPECTION & QUALITY ASSIST.							
31.E.1.-	SCHEDULE COMPLIANCE	LS	1	35,640	35,600	0	0.0%	1
31.E.2.-	QA TESTING	LS	1	32,400	32,400	0	0.0%	1
31.E.3.-	QUANTITY CALC.	LS	1	29,484	29,500	0	0.0%	1
31.E.9.-	ALL OTHER ACTIVITIES	LS	1	210,600	210,600	0	0.0%	1
31.E.Z.-	CONTINGENCIES	LS	1	16,200	16,200	0	0.0%	1
31.F.-.-	PROJECT OFFICE OPERATIONS	LS	1	64,800	64,800	0	0.0%	1
31.F.Z.-	CONTINGENCIES	LS	1	3,240	3,200	0	0.0%	1
31.H.-.-	CONTRACTOR INITIATED CLAIMS	LS	1	12,960	13,000	0	0.0%	1
31.P.-.-	PROJECT MANAGEMENT	LS	1	14,256	14,300	0	0.0%	1

SUBTOTAL CONSTRUCTION COSTS $647,900

SUBTOTAL CONTINGENCIES 0.0% $0

TOTAL 31. CONSTRUCTION MANAGEMENT (S&I) $647,900

REASONS FOR CONTINGENCIES

1. CONTINGENCIES ARE INCLUDED IN LUMP SUM AMOUNT.

NOTES:

A. FEDERAL, NONFEDERAL COST TO BE IN ACCORDANCE WITH 1986 WRDA.

APPENDIX G

CORRESPONDENCE

APPENDIX G

CORRESPONDENCE

TABLE OF CONTENTS

Item	Page
LETTER FROM MINNESOTA HISTORICAL SOCIETY 30 MARCH 1992	G-1
LETTER TO MINNESOTA HISTORICAL SOCIETY 25 FEBRUARY 1992	G-2-3
MEMORANDUM FROM CITY OF ROCHESTER 6 FEBRUARY 1992	G-4-7
MEMORANDUM FROM CITY OF ROCHESTER 4 FEBRUARY 1992	G-8
LETTER FROM CITY OF ROCHESTER 7 JANUARY 1992	G-9-10
MEMORANDUM FROM ROCHESTER DEPARTMENT OF PUBLIC SERVICES TO ROCHESTER CITY ADMINISTRATOR, 20 DECEMBER 1991	G-11
MEMORANDUM FROM ROCHESTER PARK AND RECREATION DEPARTMENT TO ROCHESTER CITY ADMINISTRATOR 17 DECEMBER 1991	G-12
LETTER FROM ST. PAUL DISTRICT TO STATE HISTORIC PRESERVATION OFFICE, 12 DECEMBER 1991	G-13
LETTER FROM MINNESOTA DEPARTMENT OF NATURAL RESOURCES TO CITY OF ROCHESTER, 24 JANUARY 1992	G-14-15
LETTER FROM MINNESOTA DEPARTMENT OF NATURUAL RESOURCES TO CITY OF ROCHESTER, 24 OCTOBER 1991	G-16-17
MEMORANDUM FROM ROCHESTER CITY ADMINISTRATOR TO ROCHESTER FLOOD CONTROL COMMITTEE, 27 SEPTEMBER 1991	G-18-21
MEMORANDUM FROM ROCHESTER DEPARTMENT OF PUBLIC SERVICES TO CITY OF ROCHESTER, 26 SEPTEMBER 1991	G-22
LETTER FROM SOIL CONSERVATION SERVICE TO CITY OF ROCHESTER, 19 SEPTEMBER 1991	G-23
MEMORANDUM FROM COUNTY OF OLMSTEAD TO CITY OF ROCHESTER 16 SEPTEMBER 1991	G-24
MEMORANDUM FROM ST. PAUL DISTRICT PLANNING DIVISION 31 JULY 1991	G-25-36

MEMORANDUM FOR RECORD BY ST. PAUL DISTRICT 12 JULY 1991	G-37-41
LETTER FROM CITY OF ROCHESTER 3 JANUARY 1991	G-42
LETTER FROM MAYO FOUNDATION TO CITY OF ROCHESTER 12 DECEMBER 1990	G-43
MEMORANDUM FOR RECORD BY ST. PAUL DISTRICT 8 MARCH 1990	G-44-45
LETTER FROM CITY OF ROCHESTER 7 SEPTEMBER 1989	G-46
LETTER TO MINNESOTA OFFICE OF LOCAL AND URBAN AFFAIRS, 3 MAY 1977	G-47-48
LETTER FROM MINNESOTA OFFICE OF LOCAL & URBAN AFFAIRS 25 MARCH 1977	G-49
LETTER FROM U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OUTDOOR RECREATION TO MINNESOTA OFFICE OF LOCAL & URBAN AFFAIRS, 9 MARCH 1977	G-50-51
LETTER TO REGIONAL DIRECTOR, BUREAU OF OUTDOOR RECREATION, FROM MINNESOTA OFFICE OF LOCAL & URBAN AFFAIRS, 21 DECEMBER 1976	G-52-53
LETTER FROM U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF OUTDOOR RECREATION, 24 MAY 1976	G-54
MEMORANDUM FOR RECORD BY ST. PAUL DISTRICT 9 FEBRUARY 1976	G-55-59
MEMORANDUM FOR RECORD BY ST. PAUL DISTRICT 30 OCTOBER 1975	G-60-63

MINNESOTA HISTORICAL SOCIET

FOUNDED IN 1849

March 30, 1992

Mr. David Berwick
St. Paul District, Corps of Engineers
180 East Kellogg Boulevard - Room 1421
St. Paul, Minnesota 55101-1479

Dear Mr. Berwick:

Re: State 4 of Rochester Flood Control Project; channel modification, Bear Creek; S1, 12, 13, T106, R14; Rochester, Olmsted County
MHS Referral FIle Number: 92-1054

Thank you for the opportunity to review and comment on the above project. It has been reviewed pursuant to the responsibilities given the State Historic Preservation Officer by the National Historic Preservation Act of 1966 and the Procedures of the Advisory Council on Historic Preservation (36CFR800), and to the responsibilities given the Minnesota Historical Society by the Minnesota Historic Sites Act and the Minnesota Field Archaeology Act.

We have reviewed the additional information transmitted in your letter of February 25, 1992 and are of the opinion that the foundation site does not appear eligible for the National Register of Historic Places. Therefore, based on existing information we conclude that no propertieseligible for or listed on the National Register of Historic Places are within the project's area of effect.

Please contact Dennis Gimmestad or Jackie Sluss of this office if you have any questions regarding our review of this project.

Sincerely,

Dennis A. Gimmestad for

Britta L. Bloomberg
Deputy State Historic Preservation Officer

BLB:dmb

Carroll

February 25, 1992

Environmental Resources Branch
Planning Division

Mr. Dennis Gimmestad
State Historic Preservation Office
Minnesota Historical Society
Fort Snelling History Center
St. Paul, Minnesota 55111

Dear Mr. Gimmestad:

Thank you for your letter of January 24, 1992, regarding the re-coordination of Stage 4 of the Rochester Flood Control Project. We understand that your office concurs with our conclusion that archaeological sites "D", "E", and "F" are not eligible for the National Register of Historic Places. However, you requested additional information about the soap factory foundation in order to determine its eligibility.

After an intensive search of the records of the Minnesota Historical Society (MHS) and Olmsted County Historical Society, we have gathered the following information.

The initial search at MHS did not reveal any information about soap manufacturing in Rochester, although we did discover that soap was produced at the State Asylum for the Insane (located well to the north of the site). None of the historic maps (including Sanborn and plat maps) indicated any building or industry at the site. Furthermore, none of the business directories for Rochester available at MHS listed any soap manufacturing or retail establishments.

However, an article written in the Olmsted County Democrat dated October 10, 1895, discussed soap production at the State Hospital. (A soap factory was built at the State Hospital sometime between 1890 and 1895.) The manager of the asylum factory mentioned in the article that he was considering purchasing the soap factory of A.B. Beach. This indicated that there was another soap factory in the vicinity.

A search under A.B. Beach's name led to another newspaper article of May 2, 1895, in which Beach is described as putting in a new steam boiler in his soap factory. Business directories at the Olmsted County library revealed that in 1891 A.B. Beach was manufacturing soap for the insane asylum. His residential address was given as 912 Beaver, which approximately corresponds to the site of the factory foundation (Beaver became 9th Avenue SE in 1917). In the 1896-97 directory, Beach is listed as a soap

manufacturer and carpet weaver, with the additional address of 907 Beaver listed for the workplace. However, in 1900, Beach is listed only as a carpet weaver and only the residential address is included.

An 1896 Sanborn overview map, which included some plats beyond the city limits, confirmed that A.B. Beach owned property in the vicinity of the site and that A.F. Nelson, the manager of the asylum factory, owned the land surrounding Beach's on Bear Creek. (Please see enclosed copies of historic maps indicating property ownership.)

The 1914 and 1922 plat maps show that Slatterly owned the property formerly owned by Beach and Nelson. Slatterly donated the land to the city in the early 1930s to create Slatterly Park. A perusal of the file on Slatterly Park at the Olmsted County Historical Society did not include any reference to the soap factory or its ruins.

District historian Jane Carroll also conducted a field survey of the site. (Please see the enclosed USGS quad map showing the current location of the site.) Carroll located the foundation at the northern apex of Slatterly Park on the west bank of Bear Creek between private homes and the creek. The foundation consists of stone piled about 3 feet high and extending about 50 to 60 feet back from the creek bank. A large portion of the wall is capped by a concrete foundation about 8 inches deep. The foundation is visible only on one side (facing south). The area on top of the foundation has been filled in with construction debris and soil and is overgrown with mature trees and shrubs.

Please review the above information and enclosed maps and send us your comments as soon as possible. As the rest of Stage 4 has already been reviewed, we would appreciate a shortened review period on this particular site. If you have any questions, please call Jane Carroll at 220-0742.

Sincerely,

Enclosures

David Berwick
Chief, Environmental Resources Branch
Planning Division

CARROLL PD-ER ____
ANFINSON PD-ER ____
BERWICK PD-ER ____

OFFICE OF THE CITY ADMINISTRATOR

MEMORANDUM

DATE: February 6, 1992

TO: Denny Stotz
Ron Halling
Deb Foley
George Fortune

FROM: Gary Neumann

SUBJECT: Agenda for Bear Creek Meeting/February 11th at 7:00 p.m.

I have prepared a tentative agenda for the meeting with the Bear Creek property-owners. I have listed several sub-points under each item which are some suggestions on the type of things which I felt we needed to cover. Please feel free to outline the items which you are responsible to present in any way which you believe will improve the presentation. My list is simply a suggestion.

c: Stevan Kvenvold
Dave Olson
Roger Plumb
John Harford
Roy Sutherland

MEETING WITH BEAR CREEK PROPERTY-OWNERS
FEBRUARY 11, 1992
COUNCIL CHAMBERS
7:00 P.M.

A G E N D A

1. Introduction - Gary Neumann
   * Purpose of the meeting
   * What we hope to accomplish: understanding of project/obtain feedback
   * Who was invited
   * Previous meeting held with the owners of homes needed for acquisition
   * Council, staff and Corps personnel in attendance
   * Please hold your questions to the end of each item

2. Flood Control Improvements Done to Date - Gary Neumann
   * The SCS reservoirs reducing flooding on Bear Creek. Schedule for completion of BR-1 reservoir.
   * Corps flood control improvements done or underway. Overall completion December, 1995.
   * Anticipated benefits - substantially reduce threat and occurrence of flooding, reduce or eliminate flood insurance, decrease building restrictions by revising flood zones.

3. Why We Are Doing the Project - Deb Foley
   * Review of past flooding

4. Proposed Schedule for Construction on Bear Creek - Deb Foley

5. Review of Proposed Design Plans - George Fortune
   * Explanation of design features
   * Channelization cross-sections
   * Maintenance needs/pathway on east side
   * Schedule for completion of plans
   * Type of construction/impacts on adjacent property-owners

6. Explanation of Pedestrian Pathway - Denny Stotz
   * Existing pathways in other stages of project. Eventual overall pathway system.
   * Pathway locations and underpasses - Bear Creek Stage
   * Pathway landscaping
   * Pathway lighting
   * Feedback

7. Right of Way Acquisition Needs - Ron Halling
   * Right of way determination process - surveying
   * Appraisal process
   * Offer process
   * Acquisition process
   * Potential right of entry process

8. Question and Answer - Gary and all

9. Closure and What Happens Next - Gary Neumann

11 Feb 92

Bear Cr Property Owner's Mtg

- Landscaping concerns
  - maintenance of riprap
  - wildflowers in trilock ?
- Neighborhood organiz involvemt - through Denny

ALL-AMERICA CITY

ROCHESTER

Minnesota

January 21, 1992

GARY H. NEUMANN
Assistant City Administrator
Room 214, City Hall
Rochester, MN 55902-3129
(507) 285-8082
FAX #(507) 285-8256

INFORMATIONAL MEETING
TUESDAY, FEBRUARY 11, 1992
CITY COUNCIL CHAMBERS, CITY HALL
BEAR CREEK FLOOD CONTROL PROJECT

An informational meeting will be held at **7:00 p.m. on Tuesday, February 11, 1992, in the City Council Chambers at City Hall** to provide information on the proposed Corps of Engineers Flood Control Project improvements for Bear Creek. All property owners who directly abut the project work limits have been invited and are encouraged to attend.

Currently, the Corps of Engineers is working to complete the preliminary design for the project along Bear Creek. An alignment for the channel has been recommended. This design phase is scheduled to be completed in May of 1992. Following this design phase, plans and specifications would be prepared between the summer of 1992 to June of 1993. Construction is tentatively scheduled from September of 1993 to September of 1995.

At the meeting on February 11, the City staff and the Corps intend to provide information on the channel alignment as recommended in the preliminary design and its impact on adjacent properties. The acquisition and construction phases of this project will require the acquisition of some homes and businesses and will require the securing of easements from other adjacent properties where outright acquisition is not required. The City staff has already met with the owners of the homes and businesses which will need to be acquired.

The information that we will be able to provide at this time is still preliminary and may be subject to future revisions and mapping changes. Nevertheless, we would like to review the information which we have available at this time with you and to respond to any questions which you might have.

If you are unable to attend the meeting but have some questions regarding the Corps project as it is proposed for this area, please feel free to contact Gary Neumann at the City Administrator's Office (507/285-8082) or Ron Halling of the Public Services Department (507/281-6008) to discuss any questions you may have.

We hope to see you on February 11, 1992.

OFFICE OF THE CITY ADMINISTRATOR

M E M O R A N D U M

DATE: February 4, 1992

TO: Deb Foley

FROM: Gary Neumann

SUBJECT: Council Design Decisions - Bear Creek

The Council made the following preliminary decisions on design aspects for Stage 4:

1. They approved the channelization design which uses a 1 to 3 slope in the area from the 4th Street bridge to Slatterly Park with topsoil and a natural grass mixture (not sod) over the riprap. They wanted riprap up to a 10 year event only.

2. They approved the channelization design for the area in Slatterly Park which uses a natural channel bottom (no riprap), tri-lock in the low flow channel and grass benches. They want a natural grass mixture to be used on the tri-lock with sod to be used in the high flow channel area.

3. The Council felt that the installation of lighting would be essential for the pedestrian pathway. They agreed that a different type of globe lighting standard should be used to more efficiently direct the lighting onto the pathway and to keep as much light as possible out of adjacent homes.

4. The Council still wants to receive some additional information from the Corps and the staff on the proposed design of the drop structures in this stage. As you are aware, there is some interest in making these as aesthetically pleasing as possible. We need to discuss this further.

Please use the above information in the preparation of the plans for the meeting with abutting property-owners for February 11th. The Council does hope to receive some feedback from the property-owners on the design, especially the lighting of the pedestrian pathway.

c: Stevan Kvenvold
Roger Plumb
Roy Sutherland
Dave Olson
John Harford

ALL-AMERICA CITY

ROCHESTER

Minnesota

January 7, 1992

GARY H. NEUMANN
Assistant City Administrator
Room 214, City Hall
Rochester, MN 55902-3129
(507) 285-8082
FAX #(507) 285-8256

Deb Foley
U.S. Army Corps of Engineers
St. Paul District
1421 U.S. Post Office and Customs House
St. Paul, Minnesota 55101-1479

RE: City of Rochester Comments - Stage 4 Plans

Dear Deb:

The following are the comments of the City of Rochester on the Design Memo plans for Stage 4:

1. A pathway to serve as both a pedestrian and maintenance path should be shown on the west side from the 6th Street bridge to Slatterly Park.

2. If a maintenance path is not feasible on the west side throughout the project length, access to both sides of the drop structures should be provided at a minimum. The staff will want to discuss further with the Corps how maintenance will be able to be provided in the area on the west side from 4th Street to 6th Street. If mowing or weed maintenance will be needed, we will need to have some access to the west side of the channel, also.

3. An additional connection from 10th Avenue to the adjacent pedestrian path may be needed at the south end of 10th Avenue.

4. The City will work with the Corps to design the pathway on the east side from 8-1/2 Street SE to the Highway 14 bridge. The Park Department has suggested that if the pathway could meander through the wooded area in some spots instead of being along the river for the entire length, it would improve the design.

5. The City favors the levee alignment which extends to the south of the Resurrection Church. A question has been raised over whether the levee alignment would affect the existing bleachers by the Mayo High School stadium. This will need to be checked, and the alignment might need to be moved to the east to avoid the bleachers if they are affected.

6. The City agreed with the revised levee design to shorten and lower the levee.

7. A trail connection should be made to the Bear Creek Park parking area on the east side of Bear Creek south of the Highway 14 bridge.

8. As you are aware, the City is concerned about the amount of exposed riprap shown in the design plans for Stage 4. Previous plans shown to the citizens of this area during the initial design work in 1976-78 showed pedestrian paths and grass in the channel and did not show visible riprap. The City requests that alternatives be considered to remove the riprap from the area above the frequently flooded area (10 year flood). We may also be willing to consider the use of natural grasses or ground covers instead of grass in some areas where sod over riprap or geotextile fabric is being considered.

9. Tri-lock slope protection should be used on the east side north of the 4th Street bridge to match the existing tri-lock.

10. The City has not reached a final decision on whether a total taking of the bowling alley property would be needed. We are retaining a second appraisal and are researching this matter further. The plans should currently assume that the City will not be acquiring the total bowling alley facility. However, this might be subject to revision at a later date.

If you have any questions, please give me a call.

Sincerely,

Gary Neumann
Assistant City Administrator

c: Stevan Kvenvold
Dave Olson
Roger Plumb
Ron Halling
Roy Sutherland
Denny Stotz
John Harford

ROCHESTER

Minnesota

DEPARTMENT OF PUBLIC SERVICE
1602 4th Street S.E.
Rochester, MN 55904-4718
(507) 281-6008
FAX #(507) 281-6216

December 20, 1991

TO: Gary Neumann

FROM: Roger Plumb

RE: Bear Creek Stage 4 Review

1. It's good to see the underpass design on the three major streets; i.e. 4th Street, 6th Street and 12th Street.

2. Could the project be shortened by 100-150 feet to avoid removal and replacement of the Bear Creek Park pedestrian bridge to Mayo High?

3. The City should ask the County to start a study of extending the Bear Creek path system out to Chester Woods park.

FAX to Dube-Fisher told.

ROCHESTER PARK AND RECREATION DEPARTMENT

M E M O R A N D U M

DATE: December 17, 1991

TO: Gary Neumann

FROM: Denny Stotz

SUBJECT: Stage 4 Bear Creek Design Review

The extensive use of rip rap is a concern both from an aesthetic and maintenance perspective. We should look at reducing the amount of rip rap.

The use of tri-lock slope protection should be continued in the area north of 4 Street SE to match the existing 1B3 tri-lock.

There appears to be adequate room to add a trail section on the west side of the channel from 6 Street SE extending southerly to the proposed location of the pedestrian bridge at Sta 39+00. This trail could access 9 Avenue in the vicinity of house #612, have an access at 8 Street SE and provide for good neighborhood circulation as well as provide a hard surfaced maintenance access to the channel.

The trail alignment south of 8½ Street SE could meander away from the channel, go through some existing wooded areas, swing back to the channel and then leave the channel area again. There is adequate public land in the area to create some variations in the trail alignment.

Could the amount of rip rap in the Slatterly Park and Bear Creek Park be reduced if the channel were made wider? It may be in the City's interest to sacrifice more land for the channel if the slopes can be turf, sod over rip rap or some other more aesthetic slope treatment.

A direct trail access should be shown leading from the north Bear Creek parking lot to the new trail--this could be shown as using the existing trail.

cc: Roger Plumb
Roy Sutherland

A:\WP5201\PROJECTS\STA4.001

December 12, 1991

Environmental Resources
Planning Division

Mr. Dennis Gimmestad
State Historic Preservation Office
Minnesota Historical Society
Fort Snelling History Center
St. Paul, Minnesota 55111

Dear Mr. Gimmestad,

As part of our continuing effort to "re-coordinate" the Rochester Flood Control Project with your office, please find enclosed information on Stage 4 of the project. The objective of Stage 4 is to provide flood protection for the city of Rochester against the flooding of Bear Creek. (Please see enclosed map showing reach of Stage 4 and a drawing showing the various features of the stage).

This stage consists of approximately 7,000 feet of channel modifications from the confluence of Bear Creek upstream to Mayo High School. These include: widening and deepening the existing channel; the construction of two drop structures, and construction of about 7,000 feet of levee. Recreational features include bicycle and pedestrian paths along the flood control channel.

As indicated on the enclosed list of surveys, the Bear Creek reach has been studied both specifically and as part of the general surveys of the Rochester project. As with the other stages of the Rochester project, borrow and disposal sites will continue to be coordinated separately, as they arise.

Please review the enclosed information and send us your comments by January 13, 1991. If you have any questions, call Jane Carroll at 220-0742.

Sincerely,

Enclosures

Jody L. Rooney
Chief, Environmental Resources Branch
Planning Division

MINNESOTA HISTORICAL SOCIETY
FOUNDED IN 1849
Fort Snelling History Center. St. Paul, MN 55111 • (612) 726-1171

January 24, 1992

Ms. Jody L. Rooney
St. Paul District, Corps of Engineers
1421 U. S. Post Office & Custom House
St. Paul, Minnesota 55101-1479

Dear Ms. Rooney:

Re: Rochester Flood Control Project Stage 4; channel modification
Bear Creek - S1, 12, 13, T106, R14, City of Rochester, Olmsted County
MHS Referral File Number: 92-1054

Thank you for the opportunity to review and comment on the above project. It has been reviewed pursuant to the responsibilities given the State Historic Preservation Officer by the National Historic Preservation Act of 1966 and the Procedures of the Advisory Council on Historic Preservation (36CFR800), and to the responsibilities given the Minnesota Historical Society by the Minnesota Historic Sites Act and the Minnesota Field Archaeology Act.

We concur that archaeologist sites "D', "E", and "F" are not eligible to the National Register of Historic Places. However, we do not believe that there is adequate information in order to determine whether the soap factory ruin is eligible. We would appreciate further discussion of the eligibility of this property.

After the eligibility of this site has been clearly established, we will be able to determine the effects of this stage of the project on historic resources.

Please contact me if you have any questions regarding this review.

Sincerely,

Dennis A. Gimmestad
Government Programs and Compliance Officer

DAG:dmb

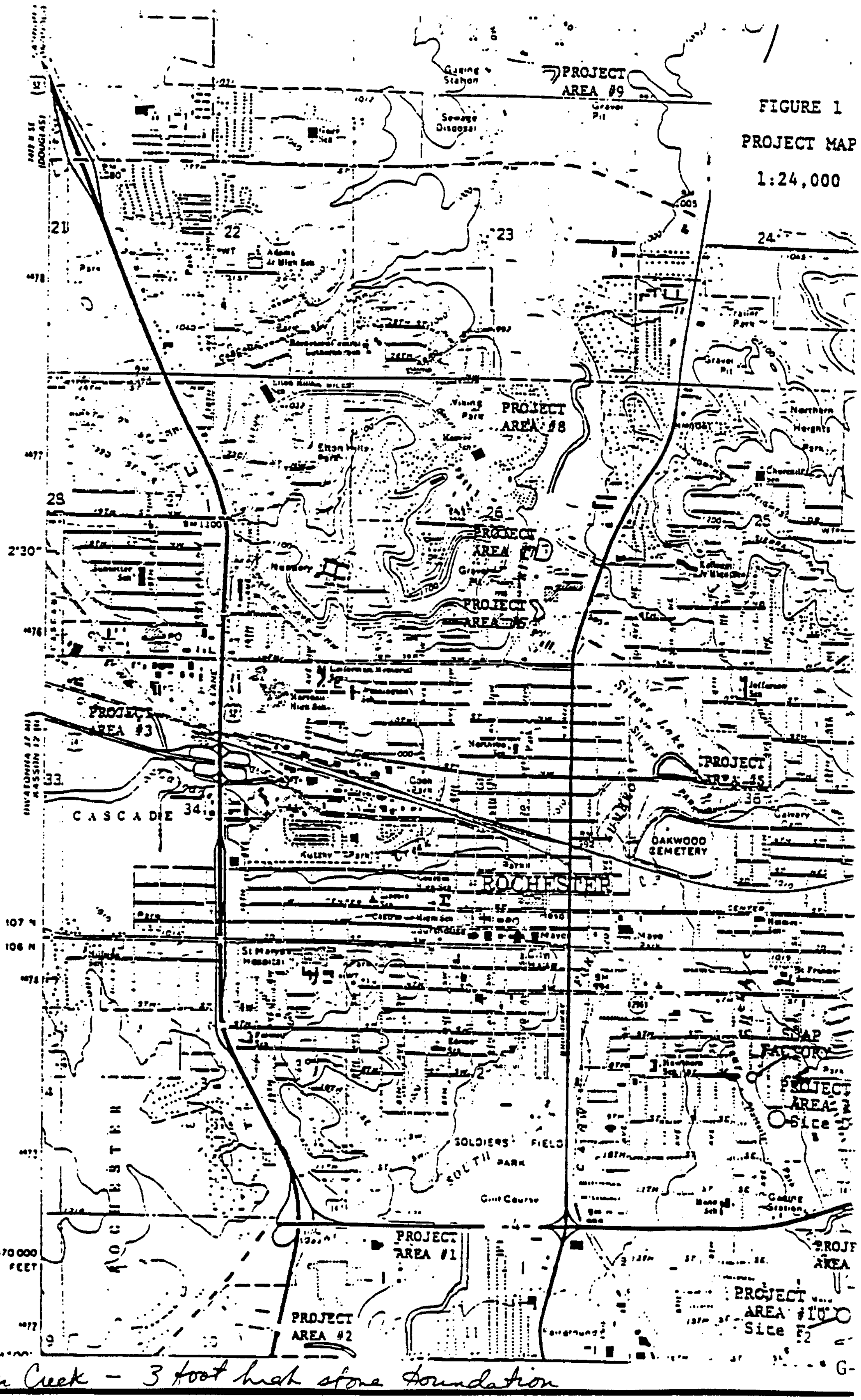


FIGURE 1

PROJECT MAP

1:24,000

soap factory site = roughly intersection of 8th St SE (?) + 10th Ave SE (?)

→ North end of Slatterly Park ... West bank of Bear Creek – 3 foot high stone foundation

STATE OF
MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
500 LAFAYETTE ROAD • ST. PAUL, MINNESOTA • 55155-40____

DNR INFORMATION
(612) 296-6157

October 24, 1991

Gary Neumann, Asst. City Administrator
City of Rochester
Room 212, City Hall
Rochester, MN 55902-3129

Dear Gary:

RE: REDUCTION IN SCOPE AND LEVEL OF PROTECTION OF BEAR CREEK PORTION OF ROCHESTER FLOOD CONTROL PROJECT

This is in response to the meeting held September 16, 1991, concerning a proposal to reduce the scope and level of flood protection for the Bear Creek portion of the Rochester Flood Control Project. Preliminary information on the new proposal indicates the flood protection level would be reduced such that 54 more homes would be subject to flooding that otherwise would be protected under the current general design memorandum project. We are reluctant to support an alternative that removes anticipated protection from so many homes, even though it might result in significant cost savings.

As you know, the Department is responsible for implementing the State's floodplain management and flood damage reduction programs as well as managing the natural resources of the State. In exercising this responsibility the Department several years ago, subject to the mitigation of certain fish and wildlife habitat losses, sanctioned the entire Rochester Flood Control Project as proposed by the Soil Conservation Service and the U.S. Army Corps of Engineers in the general design memorandum.

Since preparation of the general design memorandum, environmental requirements have become more stringent. Thus if the City chooses to pursue the reduced project scope, the Department might treat such a major modification as a new and separate project and this may require that additional mitigative measures be investigated.

To conclude, the preceding remarks should be considered preliminary only. The final position of the Department can only be formulated after our affected disciplines have had adequate opportunity to review plans of the modifications and all related impacts. Please let us know how you wish to proceed with this proposal.

City of Rochester
Page Two

In the meantime, if you have any questions regarding this matter don't hesitate to contact Joe Gibson at (612) 296-2773.

Sincerely,

DIVISION OF WATERS

Paul T. Swenson, Acting Administrator
Permits and Land Use Section

PTS/JFC/JG:fw

cc: Kent Lokkesmoe, Director
Bill Johnson, Regional Administrator
Mark Heywood, Regional Wildlife Manager
Jim Cooper, Regional Hydrologist
Deb Foley, Corps of Engineers
Rob Romocki, Soil Conservation Service

OFFICE OF THE CITY ADMINISTRATOR

M E M O R A N D U M

DATE: September 27, 1991

TO: Flood Control Committee

FROM: Gary Neumann G.N.

SUBJECT: Potential for Modified Design - Bear Creek Corps Project

You will recall that the Council previously reviewed and gave an indication of preliminary approval for a revised channelization design for Stage 3 of the Corps project, Cascade Creek. In that instance, it was found that a reduction in the amount of construction would reduce the flood protection levels to a 100 year flood protection level instead of the greater protection provided by the 170 year flood protection level which had been previously planned. However, the reduction to the 100 year level would save several million dollars and that, if the 100 year protection was provided, a 170 year flood would potentially affect only 2 businesses. Other factors which helped influence the Council's decision were that the 100 year protection modified design had a positive cost-benefit ratio under Corps guidelines and that Cascade Creek has not experienced a flood in excess of a 50 year event, to date.

Recently, the Corps of Engineers has begun the design process on Stage 4, Bear Creek. In conjunction with this, the Corps has also re-analyzed the design for Bear Creek to determine if a reduction in the flood protection level for Bear Creek may also be warranted. I have attached for your information a pros and cons sheet which was provided by the Corps to help the City analyze this matter, as it is a more complicated decision than the Cascade Creek decision. I have also attached some information from other City Departments which have reviewed this matter and from the DNR and the SCS. The staff recommendation is to stick with the current 170 year flood protection plan as I will explain.

The main advantage of the redesign 100 year protection plan is that it may save several million dollars in construction costs and some areas of streambank would not need to be disturbed. However, the estimated cost savings which is shown of $8-9 million is overstated according to information which I have received from Corps budgetary officials. Still, however, the savings would be substantial. In addition, no channelization would need to be done in the downstream end of Bear Creek or in Bear Creek Park. Also, the proposed flood levee which is to extend southward from Highway 14 to 20th Street SE past Mayo High School would be eliminated. These all represent substantial advantages.

However, I believe that these advantages are substantially outweighed by the following disadvantages. First, unlike the Cascade Creek situation, 9 residences would remain within the 100 year floodplain under the modified plan and another approximately 35 residences would remain subject to flooding by a 170 year flood event which would have been protected by the authorized 170 year flood protection design. Where the reduction on Cascade Creek affected only 2 businesses, the potential reduction along Bear Creek would affect approximately 44 residences.

Second, the 1978 flood along Bear Creek was substantially in excess of the authorized 170 year flood protection plans. If a flood of the magnitude of the 1978 flood again occurred, flooding levels on Bear Creek would be 2 feet to 6 feet higher in some areas under the 100 year design than they would be under the 170 year flood protection design. Based on our past experience of having already had one flood along Bear Creek in excess of the maximum project which we would be constructing under the 170 year design, it is my feeling that the community and the residents along Bear Creek would want the City to get the maximum flood protection which the City could reasonably afford; that is the 170 year flood protection design. It would appear to me to be problematic to attempt to explain to Bear Creek residents that we can accept a lower level of flood protection on Bear Creek than for other areas of the community along Cascade Creek or the Zumbro River.

Third, the revised 100 year design has been calculated to have a cost/benefit ratio of less than 1.0, while the 170 year design has a cost/benefit ratio of 1.2. This ratio was extremely important in justifying the worth of the total project to Congress. The Washington Office of the Corps has already advised the St. Paul Office that the modified design on Cascade Creek will be considered as a separable element in the project which will have to be separately justified based on the cost/benefit ratio of the revised Cascade Creek design. Fortunately, the modified design for Cascade Creek has a ratio well in excess of 1.0. The St. Paul Office believes it will be easy to justify the revisions on Cascade Creek. However, they are very concerned that the ratio of less than 1.0 for the 100 year design on Bear Creek will be difficult to justify and may jeopardize the federal funding for Bear Creek flood control improvements. I do not believe that we should risk the loss of federal construction funds for Bear Creek.

Fourth, the flooding that has occurred on Bear Creek has occurred rather rapidly with the Creek rising, at times, 2 feet per hour. This makes flooding on Bear Creek a potentially life threatening situation with little time for evacuation. Greater protection and greater evacuation time would be provided by the 170 year flood protection design.

RECOMMENDATION:

For all these reasons, the staff would recommend that we stay with the current 170 year flood protection design. We would also recommend that the Corps continue to review the design to achieve whatever reasonable savings in cost can be accomplished without reducing the protection level below 170 year flood protection.

I would like some guidance from the Flood Control Committee as to how you wish to have staff proceed on this matter. I will give you two options. First, I can poll the Committee members and can then provide a written recommendation to the remaining members of the Council to obtain their concurrence without placing this on a Committee of the Whole agenda. The alternative would be to simply place this on the agenda for a Committee meeting and to get the Council's decision in a completely public forum. I have no problem with either approach. However, I do feel that the first approach might avoid needlessly raising anxieties for Bear Creek property-owners. If you feel that Bear Creek residents would like and would benefit from a public discussion of this, it can be scheduled for a meeting.

c: Stevan Kvenvold
Roger Plumb
Ron Livingston
Deb Foley

BEAR CREEK STAGE 4 MODIFIED   *PROS and -CONS

* CONSTRUCTION COST REDUCTION FROM \$13–14 MILLION TO \$4–6 MILLION

* ELIMINATES IMPACT ON ~~SLATTERLY~~ Bear Creek PARK – LAND & WATER CONSERVATION FUNDED

* ELIMINATES REQUIREMENT FOR UPSTREAM LEVEE

* GREATLY REDUCE QUANTITY OF ROCK EXCAVATION

* PROTECTION SUFFICIENT FOR FLOOD INSURANCE REQUIREMENTS(?) adeqt. for 6 homes and 1 business

* REDUCES OR ELIMINATES IMPACT ON BOWLING ALLEY AND CONVALESCENT HOME

GDM PROTECTION	MODIFIED PLAN	1978 FLOOD (FLOOD WOULD BE REDUCED ~30% BY SCS DAMS)
9,700 CFS	8,500 CFS	~25,000 CFS
170 YEAR	100 YEAR	~2000 YEAR

– STAGE INCREASE FOR THE SPF FLOOD RANGES FROM 2' TO 6'.

– MODIFIED PLAN WOULD ONLY ELIMINATE AQUISITION OF TWO HOMES

– HOMES STILL AFFECTED BY FLOODING:	100 YR FLOOD	SPF EVENT
UNDER EXISTING CONDITIONS	43	442
WITH MODIFIED PLAN	9	397
WITH GDM PROTECTION	0	283

– BENEFIT COST RATIO FOR MODIFIED PLAN IS LOWER THAN GDM PLAN

– MODIFIED PLAN DOES NOT INCLUDE ANY CHANNEL FREEBOARD

– REDUCTION IN BIKE TRAIL AND RECREATION FACILITIES

ROCHESTER

Minnesota

DEPARTMENT OF PUBLIC SERVICES
1602 4th Street S.E.
Rochester, MN 55904-4718
(507) 281-6008
FAX #(507) 281-6216

September 26, 1991

TO: Gary Neumann

FROM: Roger Plumb *Roger Plumb*

RE: Modified Plan - Bear Creek Flood Control

We have reviewed the subject plan for a possible reduction in the flood control work planned for Bear Creek. It is our understanding that the cost reduction from the modified plan would be substantial. However, there are a number of disadvantages, including the following:

(1) The 100 year frequency flood event would still flood some housing units.

(2) The 170 year frequency flood event would impact additional houses.

(3) The cost/benefit ratio for the modified plan would be minimal and could be a problem in obtaining recertification for the modified project.

(4) Problems are presently being experienced with the stability of some existing retaining walls adjacent to Bear Creek in an area where no channel work would be performed under the modified plan.

(5) Southeast Rochester over the years has been subjected to substantial flood damage from numerous flood events.

We recommend continuing with the presently approved flood control plan for Bear Creek.

United States
Department of
Agriculture

Soil
Conservation
Service

FCS BLDG., SUITE 600
375 JACKSON STREET
ST. PAUL, MN 55101

September 19, 1991

Gary Neumann
Assistant City Administrator
Room 214 City Hall
Rochester, MN 55902-3129

Dear Mr. Neumann:

We have reviewed the information provided at the meeting in Rochester on September 16, 1991 and the profiles and velocities that the Corps of Engineers provided us.

We have no problem with the proposed modification provided a 100 year level of protection is accomplished along Bear Creek within the City of Rochester. The areas along Bear Creek that have erosive velocities should have some type of protection to prevent erosion.

The change in the channel work on Bear Creek will not affect the design of the floodwater retarding structure on Bear Creek. If the modification is accepted the breach route maps for this structure will have to be reevaluated.

JON V. DEGROOT
Assistant State Conservationist

cc: Robert Romocki, PE, SCS, Rochester, MN
John Nicholson, AC, SCS, Rochester, MN
John Brach, SCE, SCS, St. Paul, MN
Howard Midje, HDE, St. Paul, MN
Debra Foley, LCPM, CoE, St. Paul, MN

COUNTY OF Olmsted

ROCHESTER OLMSTED
PLANNING AND HOUSING
2122 CAMPUS DR SE
ROCHESTER MN 55904-4744

ADMINISTRATION	507/285-8232
PLANNING	507/285-8232
HRA	507/285-8224

TO: Gary Neumann

FROM: Ron Livingston
John Harford

DATE: Sept. 16, 1991

RE: Comments on the Flood Control Project for Bear Creek

This memo is in response to your request for comments regarding the Corps of Engineers study of an alternative and less costly design for Bear Creek. We agree with the objective of reducing the cost of the project and the impacts on the stream corridor and surrounding properties. However, this was with the understanding that there would be little or no change in the level of protection to properties in the floodplain between alternative designs.

The Corps noted a number of pros and cons for the modified design alternative. They did not provide a number of variables that could be adjusted to change the project to meet all of our needs. Given the two choices provided we would support moving ahead on the final design and construction of the GDM plan. The GDM plan provides the same level of protection - 170 to 180 year flood - as the other portions of the project that are complete. The GDM plan would provide for more protection in a Standard Project Flood than the modified plan, which is important because this stream apparently has a history of flooding at a 100 year or greater level.

Although we have recommended using the GDM plan for a final design, we think that the Corps should look closely at other alternatives including the design of the dike south of U.S. Highway 14.

CENCS-PD-ES 31 July 1991

MEMORANDUM FOR: PP-PM, D. Foley
ED-M, J. DesHarnais
ED-GH, L. Hedin

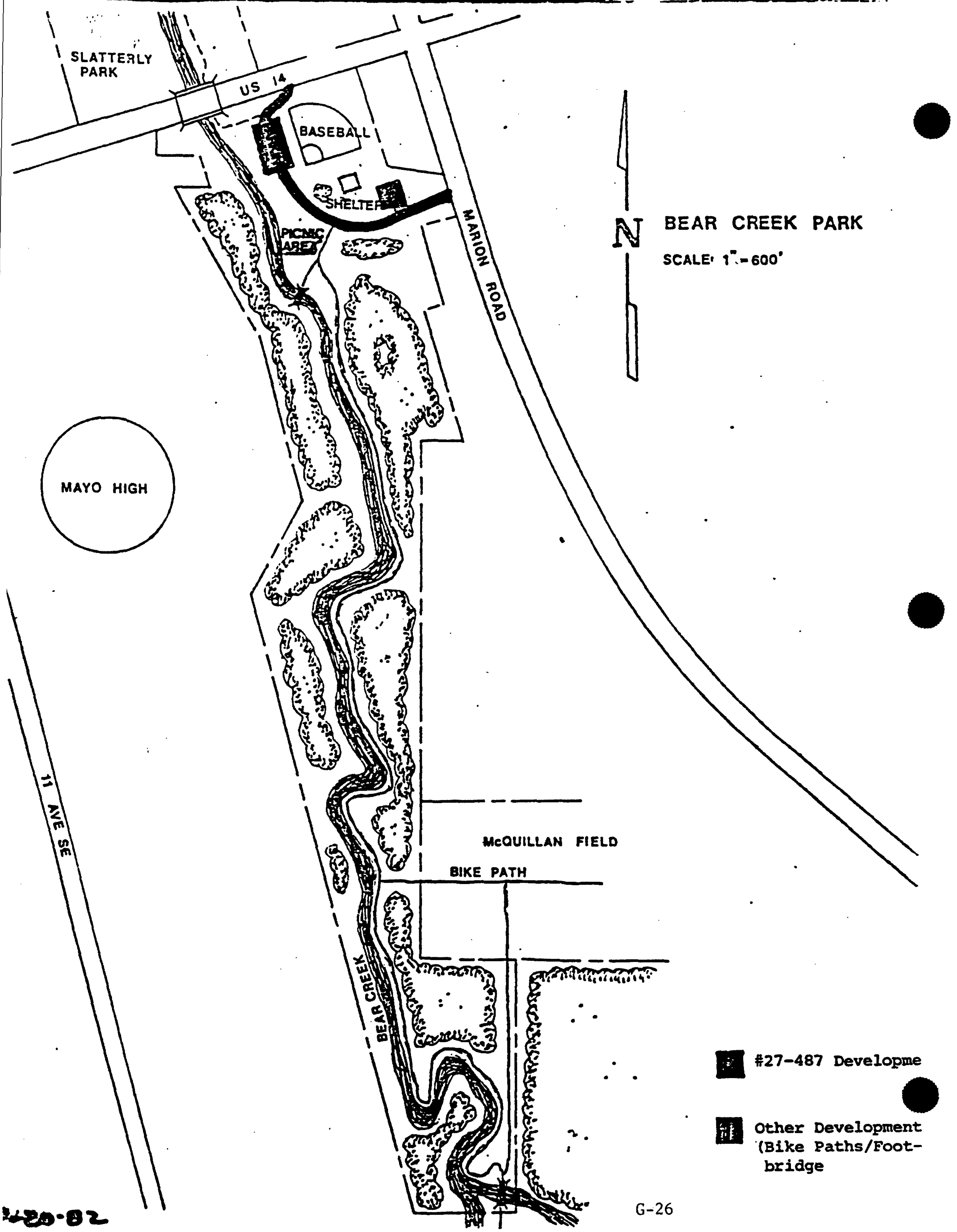
SUBJECT: LAWCON Park at Rochester - Stage 4

Bear Creek Park (located south of Highway 14) is a LAWCON park. This means that funds from the Land and Water Conservation Fund have been used for some project(s) in the park. Any land converted to a non-recreation use, regardless of what the original grant was for, must be replaced in kind based on appraised value and recreational use. The GDM alternative for Stage 4 will certainly entail going through the conversion process detailed in the accompanying "Parkland Conversion Instructions." A map of the park is on its way. Let Linda Wiley, ext. 242, know if you have questions.

Jeffrey L. McGrath

Encl

for GARY D. NELSON
Chief, Econ-Soc-Rec Branch
Planning Division



BEAR CREEK PARK
SCALE: 1" = 600'
N
SLATTERLY PARK
US 14
BASEBALL
SHELTER
PICNIC AREA
MARION ROAD
MAYO HIGH
11 AVE SE
McQUILLAN FIELD
BIKE PATH
BEAR CREEK
#27-487 Developme
Other Development (Bike Paths/Foot-bridge

PARKLAND CONVERSION INSTRUCTIONS

1. Introduction

This material is designed to assist you, the local park authority, through a process of properly converting LAWCON, LCMR and/or State Bonded assisted parkland to a different use. The Federal/State parkland conversion policy can be found in the Use of Facilities subdivision of the General Provisions section of your official LAWCON/LCMR/State Bonded Grant Agreement. The Use of Facilities subdivision states:

> The local unit shall not at any time convert any property acquired or developed pursuant to this agreement to uses other than public outdoor recreation uses specified in this project proposal attached, hereto, without the prior written approval of the Commissioner or Regional Director.

Essentially, this particular clause is the main "string" attached to the receipt of an Outdoor Recreation Grant. Because LAWCON/LCMR/State Bonded programs were created to increase the net quantity of public outdoor recreation open space, they must be protected from change and encroachment. It is counterproductive to spend time and public money to acquire and develop parkland, only to have that same land converted to non-recreational use a few years hence. Consequently, all conversions should be avoided until all other alternatives have been thoroughly explored.

We acknowledge that circumstances can exist that require the conversion of parkland to a non-recreational use. As a result, the National Park Service (NPS) has developed guidelines for converting LAWCON assisted parkland. The State of Minnesota has adopted the NPS guidelines for processing LCMR/State Bonded assisted parkland conversions. Therefore, one set of guidelines is used for conversions regardless of whether the park project was assisted with federal or state money.

2. The Process

Correctly converting LAWCON/LCMR/State Bonded assisted parkland will be a lengthy and costly process. The Federal and State governments will not provide any financial assistance to the agency which initiates the conversion unless they are directly responsible for creating the necessity to convert the parkland.

Subdivision A consists of the NPS conversion guidelines, as excerpted from the Land and Water Conservation Fund Grant Manual, Chapter 675.9.3. Subdivision B was developed by the Outdoor Recreation Grants Section to assist you through the process.

SUBDIVISION A: CONVERSION

Property acquired or developed with federal or state assistance shall be retained and used for public outdoor recreation. Any property so acquired or developed shall not be wholly or partly converted to other than public outdoor recreation uses without the approval of the NPS Regional Director or the Commissioner of Trade and Economic Development pursuant to Section 6(f)(3) of the LAWCON Act. The Director(s) has the authority to disapprove conversion requests and/or to reject proposed property substitutions.

1. Conversion applicability - Conversions generally occur in the following four situations:

   a. Property interests are conveyed for non-public outdoor recreation uses.

   b. Non-outdoor recreation uses (public or private) are made of the project area, or a portion thereof.

   c. Non-eligible indoor recreation facilities are developed within the project area.

   d. Public outdoor recreation use of property acquired or developed with LAWCON/LCMR/State Bonded assistance is terminated.

   e. Exceptions:

      * Underground utility easements that do not have significant impacts upon the recreational use of the park will not constitute a conversion.

      * Proposals to construct public facilities where it can be shown that there is a gain or increase benefit to public recreational opportunity will not constitute a conversion. Final review and approval of such cases shall be made on a case-by-case basis.

2. Prerequisites to Considerations of Conversions - We will only consider conversion requests if the following prerequisites have been met:

   a. All practical alternatives to the conversion have been evaluated and rejected on a sound basis.

   b. The fair market value of the property to be converted has been established and the property proposed for substitution is of at least equal fair market value as established by a State-approved appraisal.

      * Generally, this will necessitate a review of appraisals in accordance with Chapter 675.2 for both the property proposed to be converted and that recommended for substitution. However, at the discretion of the Regional Director or State Commissioner, a State certification that appraisals of both properties are acceptable and reveal that the replacement property is of at least equal fair market value as that of the property to be converted can be accepted. Exercising this authority should be consistent with the State's review responsibilities with respect to donation appraisals (see 675.2.5E).

* Property improvements will be excluded from all fair market value consideration for properties to be substituted. Exceptions are allowable only in those cases where property proposed for substitution contains improvements which directly enhance its outdoor recreation utility.

c. The property proposed for replacement is of reasonably equivalent usefulness and location as that being converted. Dependent upon the situation and at the discretion of the Regional Director or State Commissioner, the replacement property need not provide identical recreation experiences or be located at the same site, provided it is in a reasonably equivalent location. It must, however, be administered by the same political jurisdiction as the converted property.

d. The property proposed for substitution meets the eligibility requirements for LAWCON-assisted acquisition--replacement property must constitute or be part of a viable recreation area.

   * Public land may not be used for substitution on acquisition projects unless it meets certain acquisition criteria. However, in the case of development projects for which the state match was not derived from the cost of the purchase or value of a donation of the land to be converted, public land not currently dedicated to recreation/conservation use may be used as replacement land even if this land is transferred from one public agency to another without cost.

e. All necessary coordination with other Federal or State agencies has been satisfactorily accomplished including the State Historical Society, the Department of Natural Resources, and the U. S. Corps of Engineers if permits are needed.

f. The guidelines for environmental evaluation have been satisfactorily completed and considered by NPS or the State during their review of the proposed 6(f)(3) action. In cases where the proposed conversion arises from another Federal or State action, final review of the proposal shall not occur until NPS or the State is assured that all environmental review requirements related to that other action have been met.

g. The proposed conversion and substitution are in accord with the State Comprehensive Outdoor Recreation Plan (SCORP).

h. Staff consideration of the above points reveals no reason for disapproval and the project files are so documented.

i. It should also be noted that the acquisition of one parcel of land may be used in satisfaction of several approved conversions. However, previously acquired property cannot be used to satisfy substitution requirements.

Amendments for Conversion

Conversions require amendments when the property to be substituted is off-site or when replacement of property is deferred. Amendments should be submitted concurrently with conversion requests. Section 6(f)(3) project boundary maps shall also be submitted at this time to identify the changes to the original area caused by the proposed conversion and to establish, as appropriate, a new "project area" pursuant to the substitution. Once the conversion has been approved, replacement property should be immediately acquired. Exceptions to this rule would occur only when it is not possible for replacement property to be identified prior to the State's request for the conversion. It will, however, be the Federal or State's policy to avoid such situations, if at all possible, and to agree only if warranted by exceptional circumstances. In such cases, an express commitment to satisfy Section 6(f)(3) substitution requirements within a specified period, normally not to exceed one year following conversion approval, must be received from the State. This will be in the form of an amendment to the project agreement.

SUBDIVISION B: STEP-BY-STEP CONVERSION INFORMATION

This subdivision provides a step-by-step process designed to assure compliance with the National Park Service guidelines provided in Subdivision A. It includes a narrative, a summary with timetable and attachments.

1. The first step in the conversion process is to explore alternatives to converting parkland to a non-recreational use. Alternative exploration must be presented in a narrative form. If it is apparent that the agency initiating the conversion has made a good-faith effort to examine alternatives and still concludes that conversion is necessary, the process may continue.

2. The second step in the process is the identification of replacement land. Essentially, replacement land must:

   a. be of equal or greater appraised value; and

   b. be of equivalent recreational usefulness. (Normally, this means that the replacement land must be of equal or greater size in acres.)

3. Once tentatively selected, the replacement land will be inspected by a member of the Outdoor Recreation Grants unit to assess its recreational usefulness. This assessment is based on the site's physical characteristics, location, accessibility and the ability of future facilities to meet SCORP priorities. If, in the judgement of the Outdoor Recreation Grants staff, the replacement land appears to be of equal recreational usefulness, the conversion process may proceed. If the proposed replacement land is not equal to the land to be converted, another site must be selected.

4. The next step is to secure two appraisals. The first appraisal is for the property to be converted, the second is for the replacement property. As per the NPS LAWCON guidelines, these appraisals must be correctly prepared. The appraiser you select must be on our list of qualified appraisers. Please call the Outdoor Recreation Grants unit for the list.

5. When the two appraisals are complete, they must be submitted to the Outdoor Recreation Grants unit which has contracted with real estate experts to conduct appraisal reviews. Because the Outdoor Recreation Grants unit must pay for appraisal review services, we may require the agency initiating the conversion to reimburse us. That means you will pay for both the real estate appraisals and the appraisal review. If, after review, it is determined that the proposed replacement land is of equal or greater appraised value than the land to be converted, the conversion process may proceed. If the proposed replacement land is not of equal or greater value than the land to be converted, another site must be selected.

6. Once the appraisal process is complete, the agency which initiates the conversion must submit two copies of boundary and site maps for both the proposed conversion land and the replacement land. The replacement land site map should detail the type and location of future recreation development. A timetable must also be provided which identifies the anticipated dates of construction.

7. An Environmental Assessment Statement (EAS) must be developed for the proposed replacement land. Attachment A is a suggested format.

8. The Minnesota Historical Society must be notified of the proposed conversion. They need site maps showing anticipated future development on the proposed replacement land. It's conceivable that the Historical Society will require an archeological survey of the proposed replacement land prior to facility construction. Attachment B is a sample cover letter to the Historical Society.

9. If DNR and/or U. S. Corps of Engineers permits are needed, these must be obtained before the conversion can be submitted.

10. Once steps one through nine are complete, the proposed conversion can be submitted to the Federal NPS or State for approval. Although Outdoor Recreation Grants staff can recommend approval, we cannot guarantee it, and it is possible that your request could be denied.

11. If the conversion proposal is approved by NPS or the State, Outdoor Recreation staff will prepare formal amendments to the original project agreements. These amendments provide a legal basis for parkland conversion and replacement.

12. When the amendments are fully executed, the agency initiating the conversion is then authorized to convey the land to be converted and purchase the replacement land.

13. Once the replacement land is purchased, documentation evidencing purchase must be submitted. It consists of:

    a. Warranty Deed(s)
    b. Cancelled Checks
    c. Statement of Just Compensation Form
    d. Written Offer to Purchase
    e. Statement of Owner Form
    f. Statement of Difference in Value Form (if needed)
    g. Attorney's Certificate of Title Form

All forms plus instructions will be provided at the time of amendment execution.

14. When all items listed in number 13 are satisfactorily provided, the matter is officially closed.

OR/8-CP (1-6)

SUMMARY WITH TYPICAL TIMETABLE

	Time	Action
1.	2 - 4 weeks	Examine alternatives to converting parkland.
2.	2 - 4 weeks	Identification of replacement land.
3.	1 - 2 weeks	State inspection and evaluation of proposed replacement land.
4.	1 - 2 months	Conduct appraisals of proposed conversion and replacement land.
5.	1 - 2 months	Conduct appraisal review.
6.	Concurrent with appraisal preparation and review	Develop appropriate boundary and site plan maps on the proposed conversion and replacement land.
7.	Concurrent with appraisal preparation and review	Draft an Environmental Assessment Statement.
8.	Concurrent with appraisal preparation and review	Notify the Minnesota Historical Society.
9.	Concurrent with appraisal preparation and review	Notify the regional development commission or Metropolitan Council
10.	1 - 3 months	Submit conversion request to National Park Service or the State for approval.
11.	1 - 2 months	Prepare formal project amendments to legally authorize conversion.
12.	1 - 2 months	Conduct conveyance of land to be converted and purchase replacement land.
13.	2 - 4 weeks	Document purchase of replacement land.
	7 - 14½ months	Total length of conversion process.

OR/8-7

ATTACHMENT A

EXAMPLE OF AN ENVIRONMENTAL ASSESSMENT STATEMENT

1. Description of the Proposed Action:

   The City of Aspen Falls will acquire 18 acres containing 350' of shoreline on Aspen Lake. The City will concurrently develop the existing 32-acre park with a swimming beach, fishing pier, two picnic shelters, a multi-purpose building, nature trails, and landscaping. If financial conditions and public opinion allow, future development will include additional trails and athletic facilities.

2. Description of the Environment:

   a. Present Land Use: The parcel to be acquired and the parcel to be developed are located within the corporate limits of the City of Aspen Falls. The parcel to be acquired is concurrently zoned for residential development. There is pressure for development in this area of the city at present.

   b. Fish and Wildlife: The site is neither on nor adjacent to a national, state, or local wildlife area. Wildlife on the site consists of small mammals and birds, with an occasional deer being sighted. Fish species are primarily walleyes, northerns, and panfish. Some wildlife habitat will be list when the property is cleared and graded for the picnic shelters, multi-purpose building, and trails. Due to the size of the park, these areas will have minimal impact. There are not known endangered species on the site.

   c. Vegetation: The vegetation on the site consists of native grasses, black spruce, tamaracks, and white cedar in the lowland areas; and aspen/birch stands mingled with jackpine on the uplands. Development will be planned to remove as few of the existing trees as possible. Ground cover will be re-established upon completion of the construction. There are no endangered species on the site.

   d. Geology and Soils: The majority of soil types found on the site are characterized by six inches of silty clay loam topsoil, over 20-24 inches of clay loam subsoil. Bedrock material composed of granite schist underlies the soil mantle at a depth of 24 to 30 inches. Slopes vary from 2 to 6 percent in the upland areas to 12 to 20 percent along bluff lines near Aspen lake. Periodic outcroppings of granite are evident in the northwest corner of the site adjacent the Aspen River. Muck soils are common in the lowlying areas surrounding the marshes and the shoreline consists of sand typical of alluvial areas.

   e. Mineral Resources: There are no known mineral or peat deposits on the site.

f. Air and Water Quality: Currently, air quality on the site is excellent. Some air pollution will occur during construction and from additional vehicle trips to the site. Water quality will be affected by runoff during the construction season. The beach, shelters, and trails will be designed and constructed to discourage overuse of the area in order to avoid soil erosion and air/water pollution. The park site is not in a floodplain.

g. Historical Significance. The Minnesota Historical Society has indicated that there are no known historical or archaeological sites on the park site.

h. Transportation. Access is from County Highway 5, ½ mile east of U.S. Highway 40.

i. Energy and Taxes. Some energy will be expended during the construction phase. Also, increased vehicular visits will use energy. There will be some loss of taxes; however, the citizens of Aspen Falls feel that the addition of this recreation area offsets the loss in revenue.

3. Impact of the Proposed Action:

Short-term, unavoidable adverse effects will be the temporary removal of ground cover and subsequent erosion during the construction phase. Long-term unavoidable adverse effects will consist of the loss of habitat for small mammals, soil compaction from increased use of the area, and removal of a minimal amount of trees. Size and design of facilities will attempt to keep these adverse effects to a minimum. On the positive side, the City of Aspen Falls will be gaining a recreation area for its citizens, including improved access to Aspen Lake for fishing and swimming. The addition of this park will greatly enhance the human environment of the area.

OR/8-(8-9)

ATTACHMENT B

EXAMPLE OF A LETTER TO MINNESOTA HISTORICAL SOCIETY

State Historical Preservation Officer
Minnesota Historical Society
Attention: Ted Lofstrom
Fort Snelling
St. Paul, MN 55111

RE: FY 1988 Programmed Grant, Aspen Falls Park
City of Aspen Falls, Granite County

Dear Mr. Lofstrom:

The purpose of this letter is to request a review of the above-referenced project by the Minnesota Historical Society in compliance with state and federal regulations. The City of Aspen Falls has been programmed to receive a LAWCON and/or a state grant and is currently preparing final application to the Minnesota Department of Trade and Economic Development.

Enclosed is a summary of the project, including:

A. Project map showing type and location of proposed acquisition and development.

B. Floor and elevation plans of proposed picnic shelter buildings and multi-use building.

C. The cost of major development items and total project costs.

Previous disturbances of the proposed site include the following:

° The area of the proposed nature trail and recreation buildings, had been used for tilled agricultural fields through 1978.

° The area of the proposed swimming beach was the site of approximately ten resort cabins during the 1940's and 1950's.

The City of Aspen Falls would appreciate your timely review of our application. Please notify our office and the Outdoor Recreation Grants Section of the Department of Trade and Economic Development as to whether the proposed development would have any effect on historical or archaeological resources at the project site. If you have any questions, please call me at 218/300-0101.

Sincerely,

Orville Meyer
Park and Recreation Director

OR/8-10

CENCS-ED-GH (1110-2-1403) July 12, 1991

MEMORANDUM FOR RECORD

SUBJECT: Rochester Flood Control Project - Stage 4 - Bear Creek
Limited Modifications Alternative

1. The subject stage was reviewed prior to development of the Final Design Memorandum (FDM) to determine the feasibility of providing protection from the 100-year flood event, while significantly reducing the amount of channel modifications and length of levee required. HEC-2 computer modeling was done to determine if the modification of limited, localized channel reaches and bridge underpasses would reduce the 100-year water surface profile sufficiently to remove the majority of the Bear Creek residents from the floodplain. The channel modifications modeled, and a summary of the results are detailed below.

2. The discharge for which the General Design Memorandum (GDM) was designed is 9700 cfs, which corresponds to a flood event with a recurrence interval of 170 years. The frequency associated with this discharge assumes the construction of the three Soil Conservation Service (SCS) reservoirs in the upper section of the Bear Creek watershed. The GDM design includes two drop structures, 7030 feet of channelization, 7120 feet of levee, and 850 feet of road raise.

3. The discharge used for the limited, localized modification alternative studied here was 8500 cfs, which corresponds to a flood event with a recurrence interval of 100-years. The frequency associated with this discharge assumes the construction of the SCS upstream reservoirs. This flood event was selected as it will be the event used to determine the extent of the floodway during the restudy of the Rochester Flood Insurance Study (FIS) after completion of the flood control project.

4. There were six reaches where modifications were used to reduce the water surface profile. The location and nature of the modifications are described below. The stationing used in these descriptions references the Design Memorandum No. 1, South Fork Zumbro River, Rochester, MN. The locations of the modifications are highlighted on Inclosure 1.

- Modification #1: The temporary drop structure currently located at the interface between the subject stage of the flood control project, and Stage 1B-3 was modified. The top elevation was lowered from 980.5 to 978.5, and the topwidth reduced from 132 feet to 122 feet. A permanent drop structure would be designed for this location.

- Modification #2: The channel downstream of the 6th Ave bridge for approximately 450 feet was widened to a bottom width of 50 feet with side slopes of 1V:2.5H. The channel invert was lowered by 1.2-1.4 feet throughout this reach. The channel invert would then be approximately at the top of rock elevation. The stationing associated with this modification is 18+50 to 23+00.

- Modification #3: The channel section through the 6th Ave bridge was modified, but the structure itself left unchanged. The modified channel section had a bottom width of 88 feet, a channel invert of 982.0, and side slopes of 1V:2.5H until intersection with the abutments. This channel section is 14 feet wider, and 1.6 feet lower than the existing section. Tests indicate that lowering the channel invert 1.6 feet is likely to require some rock excavation.

- Modification #4: The channel upstream of the 6th Ave bridge was modified for a distance of approximately 1400 feet between Station 23+70 and Station 37+70. A channel section with a bottom width of 50 feet and side slopes of 1V:2.5H was established. The channel invert through this reach were lowered up to 3.6 feet. Tests indicate that this lowering of the channel invert is likely to require some rock removal.

- Modification #5: The channel downstream of the westbound U.S. Hwy 14 bridge was modified for a distance of approximately 800 feet between Station 52+50 and Station 60+50. A channel section with bottom width of 60 feet, and side slopes of 1V:3H was established. The channel invert through this reach was not changed from existing.

- Modification #6: The westbound bridge at U.S. Hwy 14 was modified. This bridge is currently scheduled for replacement by the Minnesota Department of Transportation (MNDOT). A channel section with a bottom width of 104 feet, side slopes of 1V:2H, and an invert elevation of 992.1 was established. The low chord of the bridge was modified from 1004.1 as currently designed by MNDOT to 1005.0 to assure that pressure flow conditions do not occur. The eastbound U.S. Hwy 14 was left unchanged. (Note: The original existing conditions HEC-2 model did not include both of these bridges. Both of them are represented in the localized, limited modifications model to assure that conservativism of design is appropriately considered.)

5. The sum total of these modifications is construction of a new drop structure, approximately 2800 feet of channel modification (including some rock excavation), channel modification at 6th Ave bridge, and replacement of U.S. Hwy 14 bridge with channel modifications. The water surface and channel invert profiles for existing and modified conditions are shown on Inclosure 2. As mentioned previously, the replacement of the U.S. Hwy 14 bridge has already been scheduled by MNDOT, independently of the flood control project construction. MNDOT has been very cooperative in providing current designs, and incorporating flood control needs.

6. With these modifications in place there are still a number of structures that are effected by the 100 year flood event. These structures include one business, six houses, two park buildings, one garage, and three sheds. Also, approximately 720 feet of C.S.A.H. 1; 11th Ave. S.E., near its intersection with U.S. Hwy 14 is inundated by up to 4 feet.

7. The largest concern with the localized, limited modifications alternative is the inability to prevent overtopping of C.S.A.H. 1. If this overtopping were prevented four of the houses would no longer by effected by the 100-year flood event. Other options for preventing this overtopping, such as a road raise should be considered. It would appear to be feasible to raise the road sufficiently to prevent overtopping by the 100-year flood event, but not so high as to provide protection to the SPF event with three feet of freeboard. It should be remembered that the landward side of this roadway currently experiences flooding from the SPF event due to overtopping of an other roadway.

8. It should be noted that the localized, limited channel modifications alternative will not extend the entire length of Bear Creek; and therefore, it is not feasible to include a recreational pathway along the creek. In addition the limited modifications alternative does not include an upstream levee; and

therefore, additional disposal locations would need to be aquired.

9. The Bear Creek watershed experienced significant flooding during the July 1978 flood event. The U.S. Geological Survey estimates the the peak discharge on Bear Creek at Hwy 14 was 24,900 cfs, which is the flood of record for Bear Creeek and the South Fork Zumbro. Consideration must be given to reducing the level of protection to be provided with the flood of record having occured relatively recently.

Lisa M Hedin

LISA M. HEDIN
Hydraulic Engineer
Hydraulics Section
Geotechnical, Hydraulic
and Hydrologic Engineering Branch

Inclosures (2)

CF:	D. Foley	LCPM
	J. Desharnais	ED-M
	G. Fortune	ED-D
	P. Foley	ED-GH
	S. Dobberpuhl	ED-GH

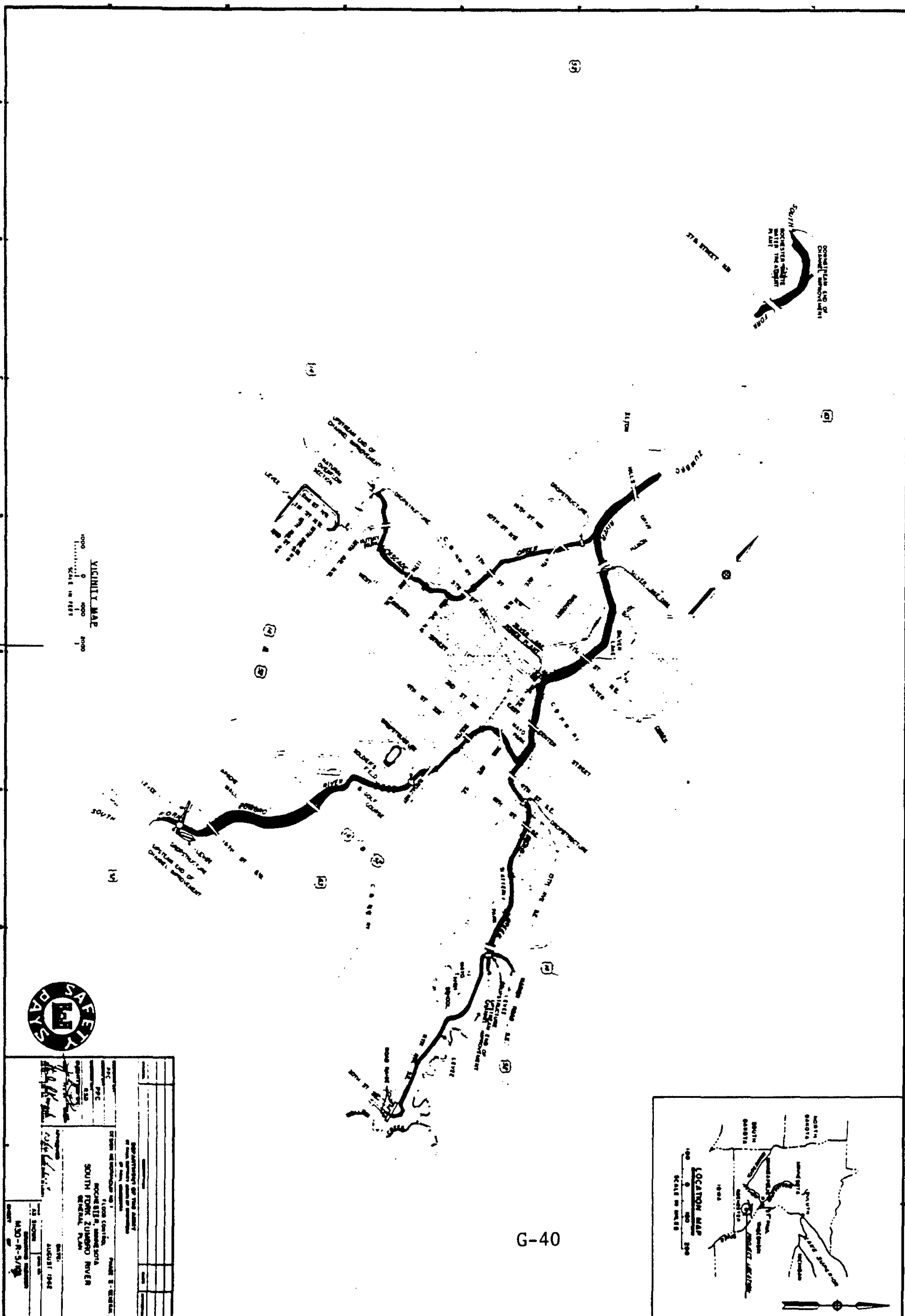
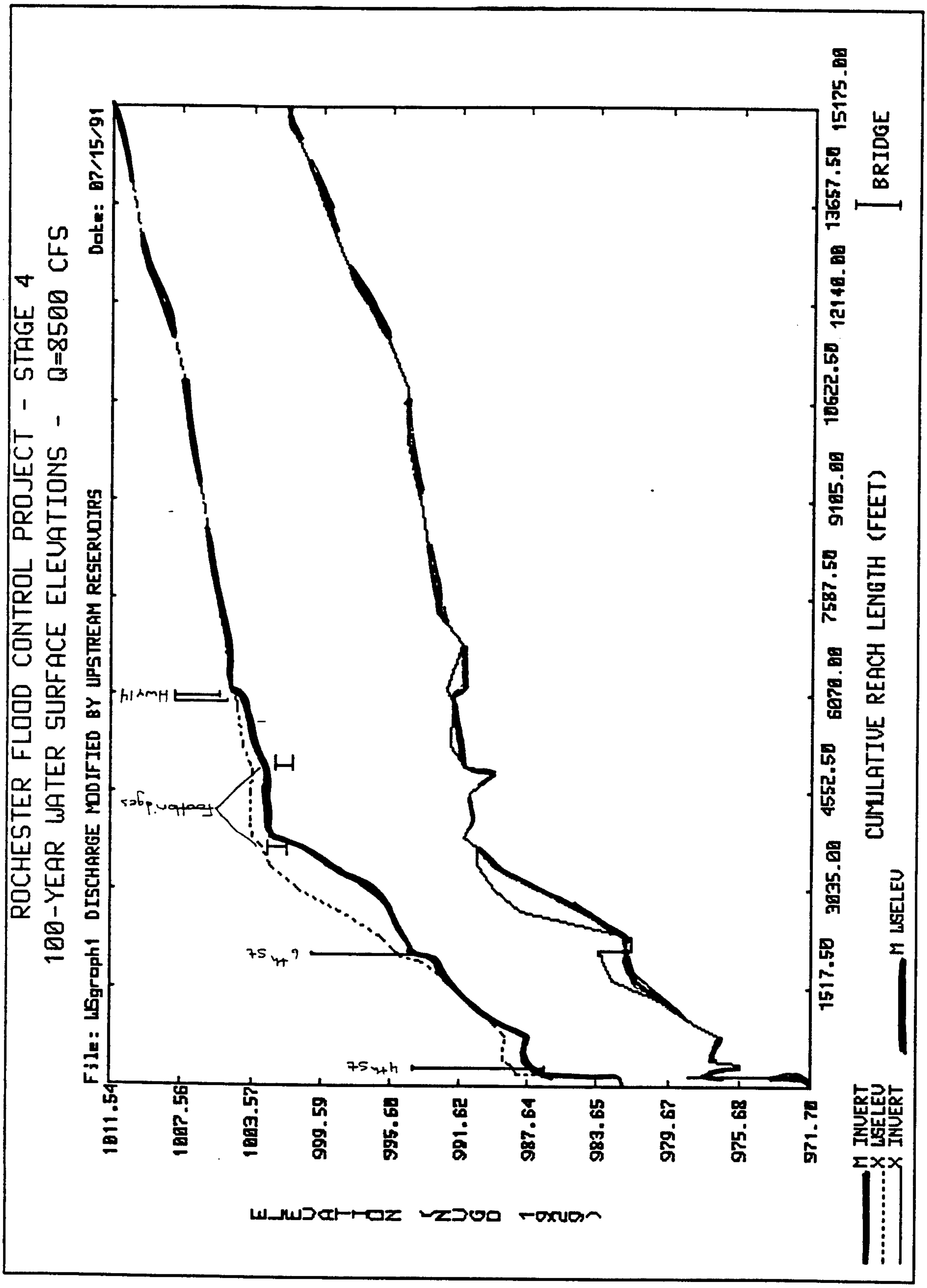


PLATE 1

INCLOSURE 1



ROCHESTER FLOOD CONTROL PROJECT - STAGE 4
100-YEAR WATER SURFACE ELEVATIONS - Q=8500 CFS
File: WSgraph1 DISCHARGE MODIFIED BY UPSTREAM RESERVOIRS
Date: 07/15/91
1011.54
1007.56
1003.57
999.59
995.60
991.62
987.64
983.65
979.67
975.68
971.70
1517.50
3035.00
4552.50
6070.00
7587.50
9105.00
10622.50
12140.00
13657.50
15175.00
CUMULATIVE REACH LENGTH (FEET)
BRIDGE
M INVERT
X WSELEV
X INVERT
M WSELEV
4th St
6th St
footbridges
Hwy 14

ALL-AMERICA CITY

ROCHESTER
Minnesota

GARY H. NEUMANN
Assistant City Administrator
Room 214, City Hall
Rochester, MN 55902-3129
(507) 285-8082
FAX #(507) 285-8256

January 3, 1991

Deb Foley
St. Paul District - Army Corps of Engineers
1421 U.S. Post Office and Customs House
St. Paul, Minnesota 55101-1479

Re: Attached Request From Mayo Foundation - Stage 4

Dear Deb:

The Mayo Foundation has requested that the City and the Corps consider whether the proposed alignment for the levee for Stage 4 south of Mayo High School could be revised to avoid taking the entire property which is owned by the Foundation in this area. I would request that the Corps provide information to the City to determine whether this would be feasible from a hydraulic perspective.

The City would also request to be advised of the effect that such a change would appear to have on the property across Bear Creek on the east side of the channel. I will request that Ron Halling or the Mayo Foundation provide a map showing the Mayo Foundation property in question.

Please provide a response to this matter within two to three weeks if at all feasible.

Sincerely,

Gary Neumann
Assistant City Administrator

cc: Ron Halling
William Pardun

Mayo Foundation Rochester, Minnesota 55905 Telephone 507 284-2511

Asset Management

December 12, 1990

Mr. Ron Halling
City of Rochester
Department of Public Services
1602 Fourth Street, SE
Rochester, MN 55904-4718

Dear Ron:

Sometime ago, you sent me a copy of the Corps of Engineers plans for the proposed dike to be built along Bear Creek from Highway 14 to approximately 20th Street SE. This plan was of interest since Mayo Foundation currently owns approximately 12 acres of land south of Mayo High School and adjacent to 11th Avenue SE.

Upon review of these preliminary plans, it appears the Corps intends to construct the dike from behind Mayo High School south along 11th Avenue SE until forced east to avoid existing structures, then coming west again to intersect 11th Avenue at approximately 20th Street SE. This plan would effectively eliminate any further possible utilization of the existing Mayo owned property.

We would like to request a review of this preliminary plan to consider moving the proposed dike back away from 11th Avenue SE to a point where it becomes a straight line from behind Mayo High School to the proposed westward curve to intersect 11th Avenue SE at 20th Street SE. It is Mayo's contention that this modification may leave our existing property with a commercially viable 200 to 300 foot deep lot with frontage to 11th Avenue SE.

Your assistance in requesting this review process or informing Mayo of the appropriate channels to initiate this request would be greatly appreciated. I have enclosed a business card for your convenience. Please feel free to contact me directly.

Sincerely,

William W. Pardun
Asset Management

WWP:akj
Enclosure

\cpm/Folw

CENCS-LCPM (1110-2-1150A) 8 March 1990

MEMORANDUM FOR RECORD

SUBJECT: Rochester, Minnesota, Flood Control Project, Stages 2B and 4

1. A meeting was held on 1 March 1990 at the Minnesota Department of Transportation (MNDOT) District Six offices in Rochester, Minnesota, to discuss MNDOT's plans for the US 14 bridges over the South Fork Zumbro River and Bear Creek. MNDOT personnel participating in this meeting were: Mr. Kermit McRae, District Engineer; Ms. Kaye Bieniek, Project Manager; Mr. Tony Hames, Design Engineer; and Mr. Darrell Christensen. Mr. Roger Plumb, Director of Public Works, and Mr. David Rossman, Traffic Engineer, represented the City of Rochester. Corps of Engineers attendees were: Ms. Deborah Foley, Project Manager; Mr. George Fortune, ED-D; Ms. Judith DesHarnais, ED-D; and Mr. Scott Jutila, ED-GH.

2. The 1982 General Design Memorandum (GDM) indicated that the existing US 14 bridges over the South Fork Zumbro River would need to be extended for the flood control project. Due to the age of the existing structures, MNDOT did not agree that extending the existing bridges was a viable alternative and they programmed the bridges for replacement. The feature design memorandum (FDM) design does not require extension/replacement of the bridges.

3. The existing bridges are nearing the end of their design life and would require replacement in 5 to 10 years. The average daily traffic load is approximately 18,000 cars per day; MNDOT feels that additional traffic lanes are needed. In addition, there are no sidewalks across the existing structures; there is heavy pedestrian traffic in this area due to the retail areas located on the west side of the bridges. Widening the existing bridges to accommodate addition of a sidewalk would be costly due to the multiple spans.

4. Mr. McRae led a discussion of the need for MNDOT to proceed with the bridge replacement as currently programmed. He noted that if the bridges were to be dropped from the MNDOT's program at this time, they would be resubmitted for replacement in about 5 years. Mr. McRae concluded that MNDOT will proceed with replacement of the bridges as currently programmed, with construction scheduled for 1993-1994.

5. Mr. McRae stated that a preliminary bridge design should be available in about 10 to 12 months. The design will probably incorporate 55- to 60-foot spans. He requested that the Corps provide the recommended hydraulic design criteria for the bridges. He also suggested that MNDOT's design could accommodate the flood control project's underpass design. Corps staff agreed to provide structural data regarding the underpass design requirements.

6. Mr. Plumb noted that replacement of the US 14 bridges should be scheduled so that it does not occur at the same time that the 2nd/3rd Avenue or 4th Street bridges are being replaced. Mr. Plumb and Mr. Rossman requested that MNDOT consider adding sidewalks to the new bridges. Mr. McRae concurred with

this request, but stated that MNDOT may require that the city share the cost of sidewalks.

7. Mr. McRae stated that the westbound US 14 bridge over Bear Creek is also programmed for replacement in 1994. A sidewalk will be added to the new bridge. Corps staff also agreed to provide hydraulic data and structural data for underpasses for this bridge. MNDOT has no plans to replace the eastbound bridge at this location in the immediate future.

8. Mr. McRae stated that funding for the US 14 bridges will be provided by the MNDOT bridge replacement program; no funds from the flood control project will be required.

9. The meeting concluded with a discussion of the proposed flood control construction near the South Broadway bridge (stage 2A). MNDOT personnel requested a copy of the plans for this area.

Deborah A. Foley
Project Manager
Life Cycle Project
Management Office

Copy furnished:

ED-D/Fortune, DesHarnais
ED-GH/Jutila
ED-M/LaFauce, Dempsey

ROCHESTER

Minnesota

September 7, 1989

GARY H. NEUMANN
Assistant City Administrator
Room 214, City Hall
Rochester, MN 55902-3129
(507) 285-8082
FAX #(507) 285-8256

Deb Foley
St. Paul District-Army Corps of Engineers
1135 U.S. Post Office and Customs House
St. Paul, Minnesota 55101-1479

RE: ALTERNATE DESIGN - STAGE 4, BEAR CREEK

Dear Deb:

The alternate design prepared by George Fortune which moves the tie-back levee further to the south and avoids the City park area is preferred by the Park Department, Public Services Department, and this office. Please proceed with that revision.

Sincerely,

Gary Neumann
Assistant City Administrator

GN/kas

cc: Stevan Kvenvold
Curt Taylor
Roger Plumb

1517-08 Zumbro Rv. - Rochester FC.

Mr. Borash/yz/7472

NCSED-PB

3 May 1977

Mr. James J. Solem
Director
Office of Local and Urban Affairs
550 Cedar Street
St. Paul, Minnesota 55101

Dear Mr. Solem:

I am writing in response to the 25 March 1977 letter from Mr. William A. Atkins of your office forwarding a letter from the Bureau of Outdoor Recreation requesting additional data on the proposed Mayo High School levee at Bear Creek Park, Rochester, Minnesota. The Bureau has determined that the levee would constitute a conflict with Section 6(f) of the Land and Water Conservation Fund Act and that mitigation lands would be required.

Inclosed are maps showing the area of Bear Creek Park that would be flooded both with and without the project. The proposed project would involve three headwaters reservoirs, channel modifications downstream from the park, and the Mayo levee. When compared to without project conditions, the proposed headwaters reservoir storage would slightly reduce the area and duration of flooding. Although we do not have maps showing comparisons for the 10-year flood, such a flood did occur in 1974, inundating most of Bear Creek Park for several hours. Again, a slight reduction in area and duration of flooding is expected with the proposed project.

A summary of peak flood flows with and without the projects is also inclosed. Detailed information on the duration of flooding is not available, but we do not expect any substantial changes in Bear Creek Park. Most floods occur in the spring or early summer and are normally less than 1 day in duration.

NCSED-PB 3 May 1977
Mr. James J. Solem

Plate 7 of the draft Phase I General Design Memorandum shows the Bear Creek Park boundaries and the estimated area which would be affected by levee and channel construction. Preparation of more detailed maps is contingent upon project approval by the Secretary of the Army and continued funding by Congress. We estimate that more detailed designs may be available in 1979 but construction is not scheduled until 1982, depending on authorization by Congress.

Approximately 10 of the 124 acres of Bear Creek Park would be occupied by the proposed levee and drop structure. The exact location and size of the levee would depend on soil borings and topographic surveys scheduled for later planning phases. Mitigation lands of equivalent value and usefulness would be available adjacent to Bear Creek Park or Zumbro Park South. We suggest that approximately 10 acres adjacent to Bear Creek Park be tentatively included in the plan as the necessary mitigation. The total acreage required should be agreed upon at this time, but the exact location of the mitigation lands could best be resolved in later planning stages when more detailed design and real estate information is available.

I trust the inclosed information will meet the needs of the Bureau of Outdoor Recreation. A letter from the Bureau indicating tentative approval of the proposed project and preliminary mitigation plan is desired for our final report.

Sincerely,

FORREST T. GAY, III
Colonel, Corps of Engineers
District Engineer

4 Incl incl. file (dupe)
1. Map showing existing 1-percent flood outline
2. Map showing 1-percent and standard project flood outlines with the proposed flood control projects
3. Table of flood discharges
4. Map showing presently estimated construction area in Bear Creek Park

KRUCHTEN ED-PB
BORASH ED-PB
NORTHRUP ED-PB
CALTON ED-PB
FISCHER ED
FAST ED
HEME DD
GAY DE

[illegible]

OFFICE OF LOCAL AND URBAN AFFAIRS

MINNESOTA STATE PLANNING AGENCY • CAPITOL SQUARE BUILDING • ST. PAUL, MINNESOTA 55101 • PHONE (612) 296-3091

March 25, 1977

Mr. Carl Borash
Army Corps of Engineers
180 East Kellogg St.
St. Paul, Minnesota 55101

RE: Bear Creek Park - LW27-00487
City of Rochester

Dear Mr. Borash:

The Bureau of Outdoor Recreation has indicated that the construction of the earthen levy at Bear Creek Park would create a 6(f) conflict and replacement lands be needed. To determine the amount of replacement lands necessary, BOR has requested additional information relating to the extent of flooding and construction limits of the project (see enclosed letter).

Mr. Curtis Taylor suggested we request this additional information from you.

Please send us this information so we can forward it to BOR. If any of the additional information requested needs clarification, prehaps you could contact Nina or our project officer Molly Balazs at the BOR office in Ann Arbor, MI (313-769-3100).

I am also enclosing a copy of the recent correspondense concerning this matter for your information.

Sincerely,

William A. Atkins

William A. Atkins, Director
Parks and Recreation Grants Section

/pkb

Enclosures

United States Department of the Interior

BUREAU OF OUTDOOR RECREATION

LAKE CENTRAL REGION
3853 RESEARCH PARK DRIVE
ANN ARBOR. MICHIGAN 48104

IN REPLY REFER TO:

G26 Minnesota
27 - 00487
xD6427 UM Zumbro

March 9, 1977

Mr. James J. Solem, Director
Office of Local and Urban Affairs
Capitol Building, Room 15
550 Cedar Street
St. Paul, Minnesota 55101

Dear Mr. Solem:

This is in response to your request for our review of a potential 6(f) conflict in Bear Creek Park which received Land and Water Conservation Fund assistance under project 27 - 00487.

The construction of an earthern levee on the edge of the park and a drop-structure across Bear Creek as outlined in the recommended flood control plan would constitute a conversion of use and would be in conflict with Section 6(f) of the Land and Water Conservation Fund Act.

An estimated six acres of land would be used to construct the levee. Only a portion of this would be within the existing Bear Creek Park. For us to determine the total impact of the project on Bear Creek Park and the amount of land converted to other uses, the following additional information is necessary:

1. Maps depicting the exact land area inundated due to the standard project flood, 100-year flood, 10-year flood, and average annual flood both with and without the project.

2. Duration curves for each of the above floods expressed in elevation and an indication of those months in which flood stages can be expected.

3. A map of Bear Creek Park on which the actual construction limits of the proposed improvements are shown.

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

We recognize that detailed maps may not be available until the advanced and design engineering analysis has been completed. When this information has been provided to this office, a determination on the extent of the 6(f) conversion that would occur should the levee be constructed can be made.

On January 24, three replacement parcels that could be utilized to satisfy the 6(f) conversion at Bear Creek Park were discussed with representatives of your office. The location of all three parcels appeared acceptable. However, a final determination on replacement lands cannot be made until the acreage of converted lands has been established and land values have been determined.

Sincerely yours,

Richard D. Rieke

Richard D. Rieke
Assistant Regional Director

December 21, 1976

Mr. John D. Cherry
Regional Director
Bureau of Outdoor Recreation
3853 Research Park Drive
Ann Arbor, MI 48104

RE: 27-00487 - Bear Creek Park
City of Rochester

Dear Mr. Cherry:

The U.S. Corps of Engineers and Soil Conservation Service are developing a series of proposals to control flooding through the City of Rochester and surrounding vicinity. The proposed improvements may create a potential 6f conflict in Bear Creek Park and we request a determination if such a conflict would result.

The Corps of Engineers has recommended three alternative treatment methods in and adjacent to the park shown on the attached map. The preferred method of treatment as recommended by the city park board would be to build an earthen levee edging Bear Creek Park and crossing the river in one location. The levee would be 10 to 15 feet high and 100 to 130 feet wide at the base. A drop structure would be constructed across Bear Creek to channelize flood waters back into the river. The levee structure would utilize about 6 acres of the 100 acre Bear Creek Park. It is estimated that flood waters would be in the park temporarily for only 2 or 3 days a year.

It is our feeling that the proposed levee would be compatible with the existing park development and not create a 6f conflict. Instead of converting land to non-recreational use, the proposed levee would provide opportunity for additional recreational development. The construction of this grassed levee would provide some topography change in a relatively flat park that could be used for such activities as some higher elevation scenic trail development and sledding and tobogganing areas in winter. In addition, the levee would help preserve the present quiet hiking trail and picnicking uses from the following.

1. Reduce noise from active football and track use at the adjacent public high school west of the park.

2. Reduce noise and screen views of vehicular traffic on U.S. Highway 14 and 52 north of the park.

3. Screen out views of a commercial trailer park adjacent to the north cart corner of the park.

If there are any questions on this or additonal information needed, please feel free to contact us.

Sincerely,

James J. Solem, Director
Office of Local and Urban Affairs

/pkb

cc: Carl E. Borash

United States Department of the Interior

BUREAU OF OUTDOOR RECREATION

LAKE CENTRAL REGION
3853 RESEARCH PARK DRIVE
ANN ARBOR, MICHIGAN 48104

IN REPLY REFER TO:
D6427UM Zumbro
XG26 MINN 27-00487

May 24, 1976

Major Norman C. Hintz
Acting District Engineer
U.S. Army Corps of Engineers,
St. Paul District
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Major Hintz:

This is in response to your request for our comments on the flood control project on the South Fork Zumbro River, Rochester, Minnesota.

In order to determine whether any of the various plans in Bear Creek Park constitute a conflict with Section 6(f) of the Land and Water Conservation Fund Act, we will need maps showing the proposed location of the various plan elements through the park as well as maps of the existing and future park development. We have written the Minnesota Department of Natural Resources indicating the necessity of these maps. This proposed flood control project, as it concerns Bear Creek Park, should be coordinated with Mr. James J. Solem, Director, Office of Local and Urban Affairs, Capital Square Building, Room 15, 550 Cedar Street, St. Paul, Minnesota 55101.

We are unable to discuss the acceptability of the levee plan until we have determined its effect on park development. Once we have determined this effect and compared it to the effect of the other alternatives, we will contact your office.

Sincerely yours,

John D. Cherry

John D. Cherry
Regional Director

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCSED-PB	Meeting with Citizens Advisory Committee for Flood Control, Phase I GDM, Rochester, Minnesota

TO Memo for Record FROM Planning Br DATE 9 Feb 76 CMT 1
Mr. Stadelman/fl-7472

1. On 9 February 1976 the following attended the Citizens Advisory Committee meeting:

Dick Norman	Mayo High School
Glenn Warner	Minnesota DNR
Evar Silvernagle	Mayo Athletic Director
Doris Blinks	Sierra Club
Bill Beauseigneur	Olmsted County Planning
Ken Rose	SCS
Jim Sheehan	School District
Harry Buck	Izaak Walton League
Paul McCue	Downtown Council
Ron Schultz	Downtown Council
Gerald Alborn	2638 12th Avenue NW, Rochester, Minn.
Carl Borash	Corps of Engineers
Walt Stadelman	Corps of Engineers

2. Harry Buck, Izaak Walton League, opened the meeting with comments and observations from the January neighborhood meetings. Attendance approximated 50; very limited response from the citizens; typical apathy prevailed. Harry Buck thought there was not much that could be done to obtain a reaction from the people. The Downtown Council fully supports flood control. However, it is concerned that the public's lack of knowledge will present a future problem. The people did express their interest in keeping the water in the headwaters.

3. Dr. Sheehan and his Mayo High School associates were extremely apprehensive over the grassed floodway plan adjacent to the school, for the following reasons:

a. Taking of school property.

b. Football field ending up as a "slop trough".

c. Will pumping eliminate a water moisture problem?

d. The effect of siltation after a flooding.

e. The possibility of returning to the reservoir conduit.

f. Aesthetics of channelization questioned.

4. Resolved:

a. Dike to be seriously discussed.

b. Continuation of levee design but also a further study of alternates.

c. More information needed before a meeting with the City Council.

d. Trade-offs should not be at the expense of business and home removal.

e. Concerned over opposition from other agencies. CAC will meet with City Council after Carl Borash contacts F&WL and DNR.

f. Harry Buck to contact Bob Otto in regard to the continuation of levee. F&WL will provide guidance. Communications will be with the City Council.

5. Carl Borash envisioned the potential problems with the Mayo High School high levee:

a. Encroachment on the floodway limited with a maximum of 0.5 foot rise and an increase from bank erosion.

b. Pumping station and its high cost and maintenance.

c. The approval of the park system from the Department of the Interior.

d. The loss of river view and the possibility of the historic site being affected.

6. A nonstructural flood damage reduction plan had little support. The major social and economic impacts of evacuation would be unacceptable to the public.

7. Handouts: Plan effectiveness table, planning schedule, and a draft 5 April 1976 public meeting notice.

8. Cascade and Bear Creek residents believe in holding down costs but would like some coloring of concrete. Something other than a chain-link fence would be acceptable for safety. They would like to see a reduction in channel width to reduce relocation of homes. The CAC obtained no comment from homeowners in the Bear Creek-Sixth Street area during the neighborhood meetings.

9. Business establishments south of Fourth and Broadway would welcome aesthetic enhancement to the Zumbro River along South Broadway. Carl Borash suggested realignment of the Zumbro River channel downstream from Fourth Street. The Downtown Development Council will be asked if additional land is desired for development along the north side of the river.

10. The next meeting is 15 March 1976, 7:30 p.m., at the Nature Center.

Walter Stadelman

WALTER STADELMAN
Planning Branch
Engineering Division

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AS
CF: REading file

[illegible], Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Soil Conservation Service
316 North Robert Street
St. Paul, Minnesota 55101

~~13 February 1975~~

ANNOUNCEMENT OF A JOINT PUBLIC MEETING
FOR FLOOD CONTROL IN THE
SOUTH FORK ZUMBRO RIVER BASIN, MINNESOTA

Meeting to be held at 7:30 p.m.
~~on 13 March 1975~~
on Monday, 5 April 1976
Rochester City Hall
~~OLMSTED COUNTY~~ COURTHOUSE
~~THIRD FLOOR~~ CITY COUNCIL CHAMBERS
ROCHESTER, MINNESOTA

You are invited to attend a meeting concerning the Corps of Engineers flood control project at Rochester authorized by Congress with the Water Resources Development Act of 1974, and the status of Soil Conservation Service watershed studies on a system of small headwaters reservoirs in the South Fork Zumbro River basin.

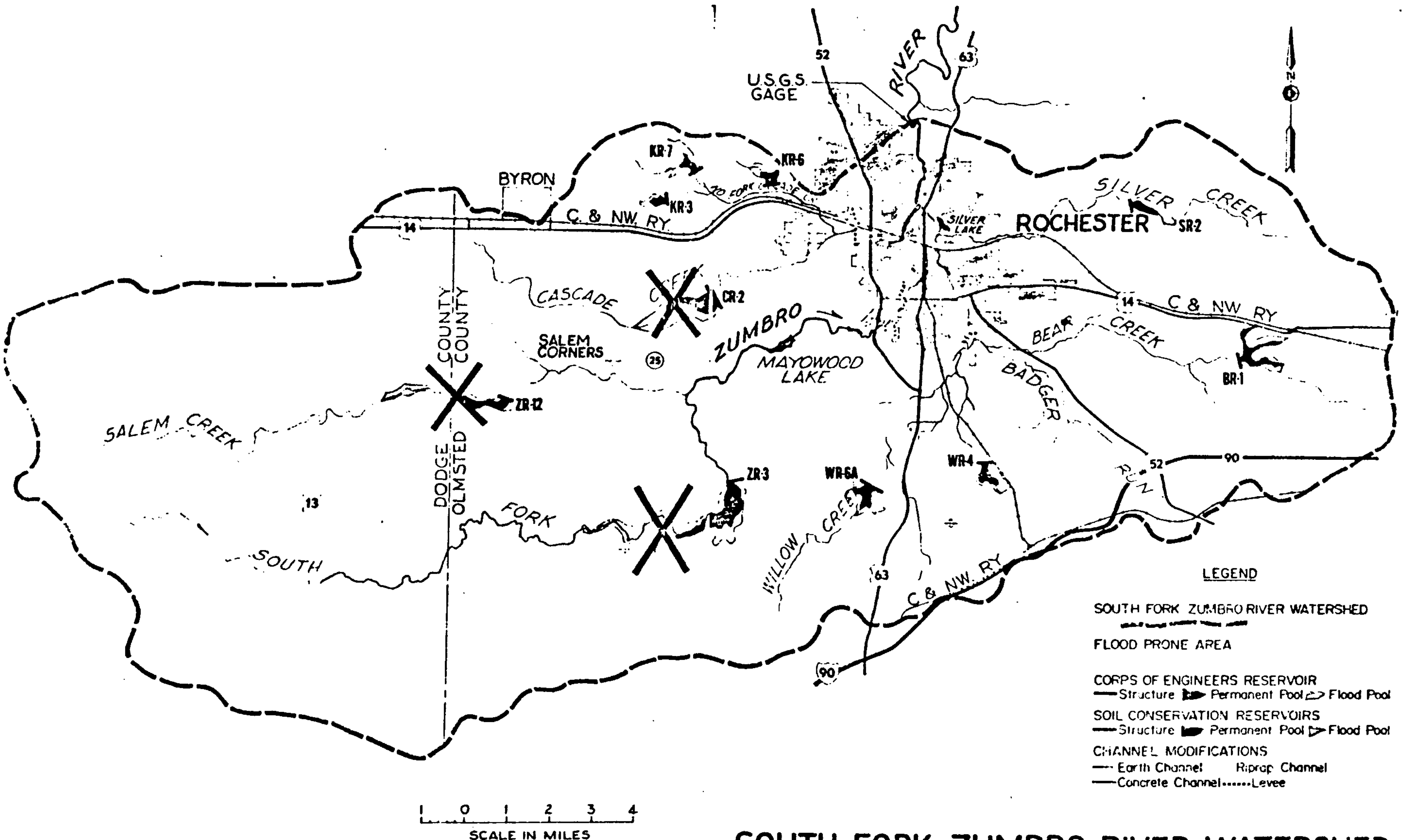
The purpose of this meeting is to assure that all interested parties have sufficient information to understand how their concerns are affected by water resource problems, to afford local interests the opportunity to express their views regarding the plans which can best solve these problems, and to provide all interests an opportunity to participate in the plan selection. Representatives of the Corps of Engineers, the Soil Conservation Service, and the State of Minnesota will be available to provide information bearing on the problem areas in the South Fork Zumbro River basin. The Corps of Engineers will discuss the flood control project at Rochester which was authorized by Congress in March 1974, the alternatives to the authorized project, the status of the project, and the future studies and plans to be developed in conjunction with the project. The Soil Conservation Service will discuss the status of the preliminary plan for a system of small headwaters reservoirs in the South Fork Zumbro River watershed, and the future studies and steps to be accomplished toward development of this reservoir system. The State of Minnesota will discuss the Minnesota Floodplain Management Act, the State and local responsibilities under this act, and the status of local floodplain management programs in the South Fork Zumbro River basin.

The Corps of Engineers flood control project authorized by Congress provides for reduction of flood damages in the floodplain areas along the South Fork Zumbro River, Cascade Creek, and Bear Creek at Rochester, Minnesota. The plan includes channel modifications; levee construction; ~~floodproofing measures~~; alterations to bridges, sewers, and utilities in the floodplain; and a river walkway corridor system. The location of these features is shown on the attached map.

Effects of Alternative Flood Damage Reduction Plans
South Fork Zumbro River Watershed

	Status Quo Floodplain Regulation + Flood Insurance	Channel Modification (100-year) + Levees + Recreation	7 SCS Reservoirs + Recreation	7 SCS Reservoirs + Reduced-Size Channel + Levees + Recreation	Permanent Evacuation (50-year) + Floodplain Regulation Recreatic
Economic					
Federal First Cost ($Million)	?	53.6	6.7	55.3	?
Non-Federal First Cost ($Million)	?	8.4	2.1	10.0	?
Total First Cost ($Million)	?	62.0	8.8	65.3	74.3
Non-Federal Operations and Maintenance Cost: Flood Control ($1,000)	?	40	19	59	13
Recreation ($1,000)	?	50	38	88	50
Flood Damages Remaining (100-year flood) ($Million)	50	1	40	1	20
Flood Damages Remaining (Million) (Standard Project Flood)	150	100	125	90	120
Benefit/Cost Ratio	—	1.3	2.7	1.2	0.9
Social					
Number of families relocated	0	12-30	3	12-30	1394
Number of businesses relocated	0	8-15	0	8-15	75
Park land added (acres)	0		250		?
Park land removed (acres)	0		0		
Effect on downstream flooding	0	Slight Increase	Decrease	Decrease	Same
More recreation opportunities	No	Yes	Yes	Yes	Yes
Cultural resource sites affected	0	5	—	5	—
Environmental					
Loss of trees along stream banks in Rochester	No	Yes	No	Yes	No
Loss of stream fishery in Rochester	No	Yes	No	Yes	No
Siltation of city channels	Same	More	Less	More	Same
Decreased streambank erosion	No	Yes	No	Yes	No
Rural land inundated (acres)	0	0	812	812	0
Slight increase in water temperature	No	Yes	Yes	Yes	No
Increased turbidity during construction	No	Yes	Yes	Yes	No
Goose wintering area quality	Same	Same	Same	Same	Same
Wildlife habitat	Same	Less	Less	Less	More

SUBJECT TO REVISION



SOUTH FORK ZUMBRO RIVER WATERSHED
MINNESOTA

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DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

REFERENCE OR OFFICE SYMBOL	SUBJECT
NCSED-PB	Meeting with the Citizens Advisory Committee, Flood Control, Rochester Phase I GDM

TO	FROM	DATE	CMT 1
Memo for Record	Planning Branch Engineering Division	30 October 1975 Mr. Visintainer/lg/7472	

1. On 23 October 1975, Messrs. Carl Borash, Frank Star, representatives from the SCS and DNR, and I attended the subject meeting. An attendance list is attached.

2. The meeting was called to order by Mr. Harry Buck, chairman of the CAC. He summarized the discussions of the 7 October CAC meeting. The inclosed agenda and information sheets were distributed to all attendees. Efforts to select a CAC secretary were unsuccessful.

3. Mr. Borash reviewed the alternative flood control measures and plans and the status of the phase I study. Noted during review of the study schedule was the public meeting currently scheduled for February 1976. Ms. Blinks reminded the committee that their recommendations for flood control in Rochester would be required by this time. Some concern was expressed over meeting this deadline.

4. An artist's conception of the proposed grassed floodway for Bear Creek adjacent to Mayo High School was shown to the group. Mayo High School representatives questioned the ground conditions that may exist in the floodway during periods of nonflooding and the costs for restoring the football field and track after floodway use. Mr. Borash said the diversion floodway control levee could be designed to allow passage of the less frequent floods thereby reducing the frequency of grounds restoration. A well point system or a tile drain field could possibly eliminate soggy conditions in the floodway during periods of nonflooding. At this time water table data is not available but will be obtained so that future ground water conditions can be anticipated. School representatives suggested that one alternative to the floodway might be to clear one side of Bear Creek and widen the channel in that direction. Mr. Borash explained that channel straightening and riprap protection would be required under this plan. He said the purpose of the grassed floodway was to preserve the natural stream and woodlands in the Bear Creek Park reach. The suggested alternative will, however, be investigated. School representatives expect to get an idea of the acceptability of the proposed grassed floodway by the next CAC meeting.

5. The city's plan for recreational development in conjunction with the flood control plan was discussed. Mr. Star explained to the committee that the policies used in determining what recreational facilities were eligible for cost sharing within project boundaries on nonreservoir projects are currently being reviewed and revised. As soon as the District receives new guidelines, and updated policies are formulated the committee as well as the Rochester Parks

and Recreation Department will be advised. The committee was informed on how the Corps will proceed in the planning of recreation facilities in conjunction with the flood control project while the new guidelines are established. The Corps will continue to work with the local sponsor on the development of conceptual and master plans. It was explained to the committee that outside the project boundaries only certain facilities could be cost shared such as; access roads to the project, parking facilities and sanitation facilities. The local sponsor has the responsibility to purchase any additional lands needed for recreation. The cost of these lands could be used as soft payment in any cost sharing agreement for recreation facilities. It was also explained to the committee that any proposed facilities would have to be justifiable under currently used demand-supply analysis in order to be cost shared. Mr. Star pointed out some of the areas being considered as additional parkland by the city and described some of the proposed facilities.

6. An artist's conception of various concrete channel treatments was shown to the group. Mr. Borash pointed out that as the degree of architectural treatment (or roughness) increases, likewise the channel width required increases. He displayed higher costs associated with various architectural treatments relative to a plain concrete channel. Slides were shown of various existing channel and park improvements. There was no reaction from the committee as to what type of treatment they favored.

7. Slides showing the magnitude of past floods and the extent of commercial and residential growth that has occurred throughout the years on floodplain lands in Rochester were shown.

8. Mr. Buck suggested that the CAC hold neighborhood meetings in affected neighborhoods of Rochester in an effort to get public feedback on proposed channel alterations. The committee favored this approach. We offered our assistance in preparation of a slide presentation and a meeting format. Mr. Buck scheduled a meeting for 4 November to work on plans for the neighborhood meetings.

9. Mr. Borash reviewed the Phase I GDM planning objectives (see inclosures). It was requested that development of the downtown business area adjacent to the streams be added to the list.

10. The CAC agreed to meet again at 1930 on 3 December 1975.

James Visintainer

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as

JAMES VISINTAINER
Civil Engineer
Planning Branch
Engineering Division

CF:
Reading file

Attendance List

	CAC Chairman
Harry Buck *	Izaak Walton League
Jerry Alborn *	
Bill Beauseigneur *	Olmsted County Planning Commission
Dorris Blinks *	Sierra Club
	League of Women Voters
Jim Denny *	
Sue Lemke *	Parks & Recreation Board
	Committee on Urban Environment
Bill Meschke *	WHSA Architect
Walter Prigge *	
Ron Schultz *	Environomics Commission
	Chamber of Commerce
	Downtown Council
Jim Sheeham	Rochester School District
Don Peterson	Ind. School District 535
Don Orke	Rochester Parks & Recreation Department
Jim Schneider	Minnesota DNR
Tom Lutgen	Minnesota DNR
Vic Ruhland	Soil Conservation Service
Frank Star	Corps of Engineers
Carl Borash	Corps of Engineers
Jim Visintainer	Corps of Engineers
Mike Robinson	Minnesota DNR

* CAC member

15 October 75

ROCHESTER PHASE I GDM

Planning Objectives

1. Reduce flood damages substantially in the Rochester area.
2. Increase recreation opportunities especially by providing new open space areas and trails along streams and lakes in Rochester.
3. Reduce stream turbidity and sedimentation in the South Fork Zumbro River Watershed.
4. Preserve the quality of Silver Lake as a wintering area for Giant Canada Geese.
5. Improve the stream fishery in the Rochester area.
6. Maintain the aesthetic qualities of the stream corridors in Rochester, particularily in park areas.
7. Minimize relocations that would have adverse social impacts.
8. Maintain existing cultural resources in Rochester.